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The Armour Engineer

VOLUME X NOVEMBER, 1917 NUMBER 1

NOTES ON THE WOOD YARD AND WOOD ROOM OF THE CELLULOSE MILL.

By C. C. HERITAGE.*

(*Member Technical Asso. of Pulp and Paper Industry.*)

In the pulp industry the chemical engineer has come to stay, for manufacturers at first slow to realize the importance of men trained technically, both in engineering and in chemistry, have now given them their opportunity and few mills are without a chemical engineer, whether he be a laboratory man, a mill superintendent, or in some cases a general manager. It is far better of course, that he be unhampered by any responsibilities save those directly connected with his engineering work when he can give his whole time to the many problems which hold possibilities of increasing the profit side of the profit and loss account. Not every problem which is run to earth will bear out the possibilities at first thought to be there, but those which do pan out are indeed the majority.

The problems which are touched upon rather briefly in this article have, in some cases, come up before and some have probably been solved in a way, while others have not. It is, therefore, hoped that some of the points here presented will serve as a stimulus for further thought and work.

Practically every mill carries a large expense in log storage, consisting of the cost of maintaining and operating a woodyard with a cableway, jammers or conveying systems. If any mill does not operate on stored wood, the cause of poor strength and quality of pulp are at once apparent—being primarily due to the use of green wood. The reason for maintaining the expensive wood yard is then to secure the proper seasoning of the wood to somewhere near constant moisture content, and perhaps a less harmful condition chemically of the resin in the wood, considering Hemlock, the latter point is eliminated.

Two recourses are open to partially or entirely eliminate the storage yard. If the time factor is essential to produce a true weathering, as many contend, then this could be shortened to a third, the present practice by sawing and splitting prior to weathering. This could be accomplished at the timber tracts where the logs are felled, especially when the pulp concern owns its own lumbering operations. The wood would then be shipped in two or four foot lengths as desired, already split; weathered for the necessary short time at the mill to produce the minimum moisture conditions, and the wood room operations would begin with the chippers. Unpeeled logs might have to go to the mill before splitting, though the barking drums in the newer installations could handle split logs as well as round. The cost of handling the wood after splitting compared with that of handling the same quantity in 16-foot lengths is problematical; the former would probably be somewhat greater but when the reduction in the size of the yard—to say nothing of other factors hinging directly on wood or constant moisture content—is taken into account, the gain is evident.

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*Class of 1904.

The other recourse lies in the mechanical drying of the chips between the sorting screens and the digesters. That this is a feasible proposition has already been demonstrated in several mills. The only objection lies in the fact that the chips may be burned unless the drier is carefully operated. Surely no engineer would consider the difficulties encountered in this operation to be greater than those already overcome in the drying of such delicate products as cork, grain, starch or any number of like materials. The elimination of a wood yard with the cost of double handling of logs and the interest on an investment of thousands of dollars in logs, land and equipment; the quicker cooking time and consequent lower consumption of steam and decreased volume of relief liquor, the possibility of carrying a higher percentage of free SO_2 in the cooking and with the same equipment, producing a lighter color and higher strength in the resulting pulp; to say nothing of uniformity of quality in the product, is set over against the one item of drying the chips. This is indeed interesting.

Now let us look at the proposition of the measure of pulp wood. This is an almost threadbare subject for discussion and yet no tangible results are evident from these discussions.

Pulpwood is purchased or scaled either by board feet or cord measure, neither of which mean anything in regard to the actual volume or weight of wood material which is to be cooked. It is not necessary to point out the variations due to diameter of log and other variables which make the actual wood material content of a cord unknown. The following figures will perhaps be of interest in connection with scaling logs by board feet measure.

Table One shows figures taken on fifteen 16-foot hemlock logs as they went to the saws. The diameter of each end and the scale was read, and then the volume represented by the scale and the actual volume were both calculated, the latter by considering the log a truncated cone. If the scale in board feet were a true measure of actual volume, then the ratio between scaled volume and actual volume would be practically a constant.

Table Two gives the same ultimate figures as Table One considering a log a simple cylinder and starting the calculation from an assumed diameter given in the first column and its corresponding scale taken from the official Wisconsin scale rule for 16 foot logs. The ratio numbers of scale volume over actual volume will, in this theoretical tabulation, be higher than in the tabulation based on actual measurement since the volume of a truncated cone is larger than that of a cylinder whose diameter is that of the small base of the cone. But the ratios in Table Two will serve to bring out the points very clearly which it is desired to make. The reader is also asked to note the curves which show graphically the data given in the two tables.

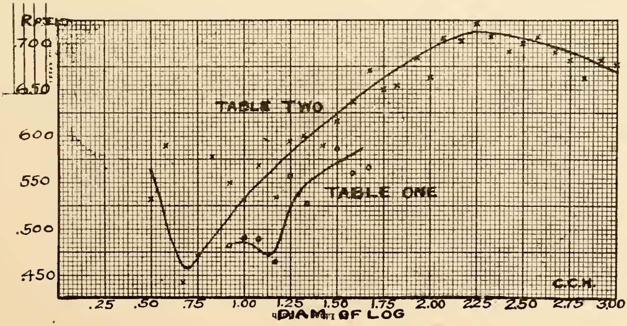


TABLE ONE.

Actual Measurements on 16-ft. Hemlock.

Log No.	Diameter Small End Ft.	Diameter Large End Ft.	Wisc'n Scale Bd. Ft.	Volume Cu. Ft. from Scale	Actual Volume	Scaled Vol. Act. Volume
4	.92	1.00	70	5.84	11.6	.503
5	.92	1.00	70	5.84	11.6	.503
11	.92	1.08	70	5.84	12.6	.463
15	.92	1.08	70	5.84	12.6	.463
Avg.	.92	1.04	70	5.84	12.1	.483
7	1.00	1.08	80	6.66	13.6	.490
8	1.08	1.33	100	8.34	18.4	.453
12	1.08	1.17	100	8.34	15.9	.524
Avg.	1.08	1.25	100	8.34	17.1	.489
6	1.17	1.33	110	9.17	19.7	.465
10	1.25	1.33	140	11.60	20.9	.557
16	1.33	1.50	160	13.30	25.2	.528
3	1.50	1.58	210	17.50	29.8	.587
17	1.58	1.83	240	20.00	36.6	.547
1	1.58	1.75	240	20.00	34.8	.575
Avg.	1.58	1.79	240	20.00	35.7	.561
2	1.67	1.75	280	23.30	36.7	.635
14	1.67	2.17	280	23.30	46.6	.500
Avg.	1.67	1.96	280	23.30	42.6	.567

TABLE TWO.

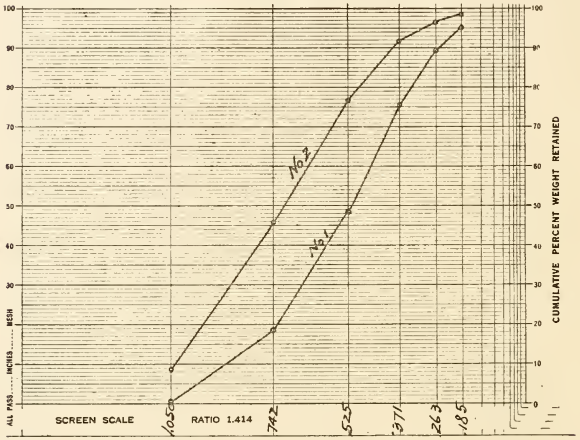
Theoretical Calculations 16-ft. Logs Assuming Logs to Be Cylindrical.

Diameter Feet	Wisconsin Scaled Bd. Ft.	Scale Volume Cu. Ft.	Actual Vol. Cu. Ft.	Scale Vol. Actual Vol.
.50	20	1.67	3.14	.532
.58	30	2.50	4.23	.592
.67	30	2.50	5.65	.443
.75	40	3.33	7.07	.472
.83	60	5.00	8.65	.578
.92	70	5.84	10.62	.550
1.00	80	6.67	12.55	.532
1.08	100	8.34	14.65	.569
1.17	110	9.18	17.20	.534
1.25	140	11.67	19.68	.594
1.33	160	13.33	22.20	.601
1.42	180	15.00	25.40	.590
1.50	210	17.50	28.35	.617
1.58	240	20.00	31.40	.637
1.67	280	23.35	35.10	.670
1.75	300	25.00	38.50	.649
1.83	330	27.50	42.10	.654
1.92	380	31.70	46.30	.684
2.00	400	33.30	50.30	.663
2.08	460	38.35	54.40	.705
2.17	500	41.60	59.20	.702
2.25	550	45.80	63.60	.720
2.33	580	48.30	68.30	.707
2.42	610	50.80	73.60	.690
2.50	660	55.00	78.60	.700
2.58	710	59.10	83.70	.707
2.67	740	61.80	89.50	.691
2.75	780	65.00	95.20	.682
2.83	800	66.70	100.80	.662
2.92	880	73.30	107.20	.683
3.00	920	76.60	113.10	.676

The Tyler Standard Screen Scale

Cumulative Direct Diagram of Screen Analysis on Sample of CHIPS

Name CHIPPERS Date DEC 4 1915



Indicate the Screen Crushed through and also First Retaining Screen	SCREEN SCALE RATIO 1.414				#1			#2		
	Openings		Mesh	Diameter Wire Inches	Sample Weights	Per Cent	Per Cent Cumulative Weights	Wgts	%	Cum %
	Inches	Millimeters								
	1.050	26.67		.149	15	.4	.4	219	8.8	8.8
	.742	18.85		.135	647	18.2	18.6	907	37.0	45.8
	.525	13.33		.105	1051	29.6	48.2	756	31.0	76.8
	.371	9.423		.092	972	27.3	75.5	370	15.1	91.9
	.263	6.680	3	.070	482	13.6	89.1	107	4.4	96.3
	.185	4.699	4	.065	209	5.9	95.0	42	1.9	98.2
	.131	3.327	6	.036	177	5.0	100.0	44	1.8	100.0
	.093	2.362	8	.032						
	.065	1.651	10	.035						
	.046	1.168	14	.025						
	.0328	.833	20	.0172						
	.0232	.589	28	.0125						
	.0164	.417	35	.0122						
	.0116	.295	48	.0092						
	.0082	.208	65	.0072						
	.0058	.147	100	.0042						
	.0041	.104	150	.0026						
	.0029	.074	200	.0021						
Pass	.0029	.074	200	.0021						
				Totals	3553			2451		

No 1
Poor Wood
3/4" Knives

THE W. S. TYLER COMPANY, CLEVELAND, OHIO

First, the measurement of pulpwood by board feet scale is no true measure of the actual quantity of wood received. It will be noted that the ratio varies from 443 in the case of an 8 in. log to .720 in the case of a 27 in. log. In other words. if all wood received was 8 in. stuff, the mill would be paying for 443 cu. ft. expressed as board feet for every 1000 cu. ft. actual volume while, if all wood received was 27 in. stuff, the mill would be paying for 720 cu. ft. expressed as board feet for every 1000 cu. ft. actual volume. Therefore, the actual wood received would cost the mill 62 per cent more in the case of 27 in. than in the case of 8 in. logs. This data is shown clearly in Table Three, which is calculated from Table 2.

Second, the measurement by board feet is far from bearing a constant relation to the actual volume and, hence, all costs, if figured to an ultimate basis of wood consumption, are bound to vary. The yield per cord or per 1000 board feet would vary assuming all other conditions throughout the manufacture to be held constant.

The fact that the calculations shown in Table Two are based on the assumption that the wood is cylindrical brings out a third point. The above assumption is practically true for large diameter stuff, unless the large end of the log actually contains the butt of the tree, for any scaler knows it is often a difficult matter to pick out the small end of a large log by casual inspection. This is never the case, however, with small diameter logs. Hence, the ratio shown in the last column of Table Two would be still smaller for small logs and more nearly the same for large ones were actual measurements used as a basis for calculation.

To sum up then, we find that small or medium diameter logs (up to 14 in.) are the best, considering cost, labor (sawing, splitting and conveying) and quality of fiber contained. The last point is true because of the larger per cent of live pliable sapwood in a small log.

A chemical engineer, in any industry, has two prime functions: The first, of which is to increase the efficiency of the process, that is, make more product or by-product from the same quantity of raw material; and the second to raise the quality of the product making the same amount of better product from the same raw material. In order to accomplish these he must, first, have an accurate measure of all raw material entering the process, which has been proven conclusively not to be the case in the pulp mill. and, second, he must have instruments and methods which will give him accurate data on the physical and chemical variables throughout the manufacture, and of the finished product itself. Uniformity of raw materials, of intermediate products and of finished product, is necessary. The last two are not possible without uniformity of operation, which in turn entails routing testing of all kinds and the elimination of the human factor as much as possible. This means money to be expended but to know whether it pays ultimately to do this, we have but to look at the example set by the leading concerns in nearly every industry who set aside from 2 per cent to 5 per cent of their gross earnings for this kind of work.

TABLE THREE.

Diameter of Log Inches	Actual Vol. (Cu. Ft.) Per 1000 Board Ft.	Cost of 1 Cu. Ft. Wood at $16.00 per 1000 B. F.
6	157	$.102
8	188	.085
12	157	.102
15	140	.114
18	135	.118
21	129	.124
24	126	.127
27	116	.138
30	119	.134
33	122	.131
36	123	.130

Let us consider some of the tests which make for uniformity of operation. Turning our attention now to the wood room, the testing of chips is of prime importance, for on their uniformity depends in great measure the strength of pulp, yield of good fiber and partial loss as screenings.

An absolute grading of chips, according to size by means of a nest of sieves, is a much more difficult operation than would appear on first sight. The important dimension of a chip is, of course, its length with the grain; the other dimensions (width and thickness) may vary more or less without materially affecting the quality of the chip. Hence, in the use of sieves of square mesh, it is easy to see how a chip ⅞ in. long by ¼ in. wide will pass through the same mesh that a chip ⅞ in. by ¼ in. long will pass, although the former chip is more desirable. However, this point could not be taken care of without giving each chip an individual inspection, which is manifestly out of the question.

The Tyler Standard Screen Scale Sieves have been found to serve the purpose of chip sizing very satisfactorily; they are very accurately made, being woven of wire of constant diameter, and being exactly the same size mesh throughout in each direction. This scale is built up on the basis of the opening in the smallest sieve equaling .0029 inches or 200 mesh as adopted by the Bureau of Standards. Then each succeeding sieve is designed so that the area of its opening shall be twice the area of the opening of the preceding one, this making the side dimension of the square increase as the square root of two or 1.414. This gives a very simple and desirable ratio of side dimension or area.

The nest of sieves necessary for chip testing are of the following dimensions:—

Side Dimension Inch	Wire Diameter Inch	Area of Opening Sq. Inch
1.050	.149	1.102
.742	.125	.551
.525	.105	.276
.371	.092	.138
.263	.070	.069
.185	.065	.035

These should be 12 in. in diameter.

The sample should be about two to three kilograms in weight —a ten quart pail full. The sample is then shaken through the various sieves as rapidly as possible and, when the separation is complete, the fractions are all weighed at or as near the same time as possible to obviate any changes in moisture and the total weight of the fractions taken as the weight of the sample. The results are then calculated to per cents by weight.

Care must be taken in the way the sieve is handled during the separation because of the physical nature of the chips. Being much thinner than they are long or broad, it is essential that the motion of the sieving be horizontal only, similar to the motion of the shaker screens, for if the chips are jumbled up and down, a chip whose breadth is much less than its length will likely be found in a much smaller fraction than it should be.

Another point to be considered is evident from inspection of the fraction retained on the 1.050 inch sieve. Many of these chips are in reality all right for their length is under 1.050 inches, but the breadth is over this figure. It is, therefore ,advisable to break these chips up by hand *with the grain* so that they will aoppear in the proper fraction of good chips.

The performance of chippers, crushers or re-chippers, and screens may be checked to good advantage by use of this sieve analysis. It is true, however, that the quality of chips coming directly from a chipper vary greatly as the ends of one "batch" of sticks come thru and the knives begin to take the next batch. It is therefore necessary to take small samples intermittently, over five to ten minutes, and cone and quarter down the resulting sample to a pail full for analysis in order to get accurate data. In the case of chipper performance, there are a good many factors of which to take cognizance.

First, the shape of the sticks fed to the chipper, taking into account the shape of the spout. On this point the writer had opportunity to compare the performance of two chippers which were identical except that No. 1 handled small split and round wood in an oval spout, and No. 2 handled all large split stuff in a spout nearly square in cross section. The comparison is given in Table Four. This data shows that the chips from the chipper, handling large split stuff, are considerably superior in every way, less oversize, less sawdust and more uniform.

Second, the grade of the wood. The more rot there is the greater will be the sawdust and the less uniform the chips.

Third, the season of the year. It is common knowledge that, during the cold months when the moisture in the wood is present in the solid phase and the logs are perhaps coated with ice and have not been put through a hot pond, the sawdust fraction is very large, and the smaller fractions of so called good chips increase in per cent. This condition also affects the knives and plates of the chipper, further augmenting the trouble.

Fourth, method of feeding chipper. The chipper spout should be kept full while the chipping is going on and should the wood not be coming fast enough to operate with the spout full continuously, then the spout should be charged intermittently. Every time a single stick or two is allowed to go through alone, the resulting chips are long and sliver-shaped.

TABLE FOUR.
CHIPPER PERFORMANCE.
Average of Daily Tests for One Month.

Retained on	No. 1 Per Cent	No. 2 Per Cent.
1.050	5.95	5.83
.742	40.57	42.43
.525	27.38	28.57
.371	14.68	14.00
.263	6.09	5.05
1.85	2.52	2.17
Thru .185	2.81	1.95
	100.00	100.00

Fifth, the condition of the chipper knives as to sharpness and bevel. The data shown in Table Five presents clearly the rapid dulling of chipper knives. These tests were taken in three groups of three tests each and the figures given are the average for each group. How essential is the frequent changing of dull knives for sharp ones, becomes at once apparent.

Sixth, condition of bed knife and of cheek and face plates. The bed knife should be ground daily and as much care taken to have it in the right condition as the cutting knives themselves, for it is apt to wear concave in a short time, which produces a varyng clearance with the moving knives. If the face and cheek plates do not present a square edge or work loose, the knives are not held rigid and the oversize fraction increases.

Seventh, clearance of cutting knives and bed knife. This should be as small as safety will permit and goes hand in hand with keeping the bed knife in good condition.

Eighth, condition of the spout. Rat holes in the corners of the spout increase the long oversized fraction; and the spouts should be relined whenever the wear makes it necessary.

Ninth, thickness or set of knife. Reference to Table Six shows that with increasing thickness of knife, the larger fractions increase in per cent, while the smaller ones decrease. These tests were made with ¾ in, ⅞ in and 1 in. knives, and the figures presented are all averages of not less than five individual tests. Even though the oversize fraction is large the reduction of the sawdust fraction is so marked that the large knives are much to be preferred.

Tenth, R. P. M. of chipper. For best results this should be from 200 to 220. Increasing speed increases per cent sawdust and per cent smaller size fractions.

Graph paper is obtainable for use with the Tyler sieves by which a cumulative curve may be plotted. From this curve the quality of the chips may be told at a glance. The curve originates at the per cent oversize and ends at the per cent sawdust, while the slope or change of slope shows the uniformity; two such curves are reproduced herewith: No. 2 represents a sample of excellent quality and No. 1 a sample of very poor quality due to small knives and round semi-rotten wood.

In checking the performance of shaker or rotary screens, it is necessary to make three chip analyses, as follows, material on, material off, and material through, or where two shaker screens are superposed, as is usually the case, four tests are necessary, as follows: Unscreened chips, oversize rejects, screened chips, and sawdust.

TABLE FIVE.

CHIPPER PERFORMANCE.

	Time Covered		
Fraction Retained on	1:10-1:30 p. m.	2:40-3:00 p. m.	3:40-4:00 p. m.
1.050	7.64	4.14	2.61
.742	42.83	36.20	35.27
.525	26.93	30.13	33.43
.371	13.30	14.63	17.63
.263	5.37	7.40	5.43
.185	2.10	4.20	3.30
Thru .185	1.83	3.30	2.33
	100.00	100.00	100.00

TABLE SIX.
CHIPPER PERFORMANCE.

Fraction Retained on	¾ in. Knives	⅞ in. Knives	1 in. Knives
1.050	4.68	5.25	8.86
.742	34.78	37.57	53.50
.525	28.82	28.42	23.58
.371	17.50	15.76	9.08
.263	8.35	6.38	2.78
.185	3.20	2.88	1.06
Thru .185	2.67	3.74	1.14
	100.00	100.00	100.00

Two points must be taken into consideration in judging screen performance, viz.: the reduction in per cent of the material it is desired to eliminate and the per cent desirable material rejected with the undesirable material. Table Seven gives data taken on a double deck shaker screen and shows a performance somewhat better than the average. The oversize fraction was reduced 78% and the sawdust fraction 87%. At the same time the good chips rejected with the oversize fraction was but 2.1%; with the sawdust 22.0%. Any improvement in these particular screens could only be accomplished in reducing the above 22.0%, and these are hardly desirable chips anyway.

As to the performance of crushers or rechippers, these machines are of low efficiency at best and the data in Table Eight gives an average test on a crusher of the radial hammer type running at 1180 R. P. M. The efficiency of reduction on this particular test is 40.7%. The per cent sawdust is reasonably low. It was found that the efficiency of reduction of a machine of this type increases as it is worked up to capacity and falls when running light.

These performance tests on the various wood room machines, as outlined above, may be conducted by any one after a little experience, and such changes made in the equipment as will reduce either oversize or sawdust or both and increase uniformity. What might be called an ideal condition would be, that all chips fall between 1.050 and .371 with 90% between 1.050 and .525. These tests should be carried out periodically, say every six months.

Analysis of chips going to the storage bin is quite as important as any of the foregoing tests and may well be made routine work. The screening system, if performing satisfactorily, will remove oversize and sawdust but can have no effect on uniformity and it is quite as essential to quality of pulp to have 90% of the chips retained on .371 sieve as to have less than 6% retained on 1.050 or less than .75% pass through .185 sieve. Then, again, the screening system may be overworked through poor chipper or crusher performance or because the wood room is being operated over capacity throughout. These conditions may be noted at once in the finished chips.

The industry is becoming more and more imbued with the idea of utilizing waste, and the greatest field for improvement along these lines lies in the wood room. The sawdust produced at various points throughout the preparation of the wood should be capable of utilization in a more lucrative way than as hog. It is generallf considered that hog has about one-fourth the fuel value of a good screenings coal, but when the fuel value of a ton of hog of high moisture content, and perhaps in frozen condition, is calculated out and the cost of handling, conveying and stoking taken into account, this value sometimes becomes a negative number in comparison with that of coal available.

TABLE SEVEN.

Shaker Screen Performance.

Fraction Retained on	Unscreened	Oversize	Screened	Sawdust
1.050	16.6	97.9	3.6	....
.742	42.8	2.1	40.1	....
.525	21.4	....	29.5	....
.371	8.5	....	19.2	.9
.263	4.3	....	5.3	2.8
.185	2.4	....	1.8	18.3
Thru .185	4.0	....	.5	78.0
	100.0	100.0	100.0	100.0

Oversize reduced 78%
Sawdust reduced 87%
2.1% Good Chips in oversize
22.0% Good Chips in sawdust

TABLE EIGHT.
CRUSHER PERFORMANCE.

Retained on Fraction	Chips Charged	Chips Delivered
1.050	98.4	58.3
.742	1.6	25.2
.525	....	9.2
.371	....	3.2
.263	....	2.1
.185	....	.7
Thru .185	....	1.3
	100.0	100.0

Efficiency = 40.7%

The writer had occasion to run several complete tests on the quantity and grade of sawdust produced in the wood room and the data is presented in Tables Nine to Eleven. These figures are for clear, sound, peeled hemlock, ranging in diameter from 8 inches to 24 inches.

The material over ten mesh could be cooked to an inferior grade of pulp, the output of which may be calculated for any size mill from the figures given in Table Eleven. For example, a 75 ton mill could make an 8 ton cook every four days. Of course, in order to do this, another screen would be necessary with sufficient storage to allow the material to accumulate until the proper quantity for cooking had been produced. In regard to the dust smaller than ten mesh, there are dozens of industries using filling and binding material and wood flour of this nature and, though the proposition would require a thorough investigation, it would wthout doubt repay the effort many fold.

TABLE NINE.
Percentage by Weight of Sawdust From Various Sources.

Source	P. C. by Weight on Logs	P. C. Each Source of Total	Bone Dry Dust Per 1000 Bd. Ft.
Jump Saws	.54	12.9	23 Lbs.
Shaker Screens	3.50	83.6	148 "
Rotary Screen	.15	3.5	6 "
	4.19	100.0	177 "

Rotary Screen Between Shaker and Chip Storage.

TABLE TEN.

SAWDUST.

Sieve Analysis Each Source.

Size	Jump Saws	Shaker Screens	Rotary Screens
Over 3 Mesh	1.20	4.62	10.70
3 to 10 Mesh	29.05	63.45	35.75
10 to 40 Mesh	58.25	27.65	29.42
Thru 40 Mesh	11.50	4.28	24.13
	100.00	100.00	100.00

TABLE ELEVEN.

Production of Sawdust by Grades.

Figures All Bone Dry.

Size	Source	Lbs. per 1000 bd. ft.	Per Cent of Logs	By Weight of Total
Over 3 Mesh	Saws	.28		
	Shaker	6.85		
	Rotary	.64		
	Total	7.77	.19	4.39
3 to 10 Mesh	Saws	6.68		
	Shaker	93.90		
	Rotary	2.14		
	Total	102.72	2.44	58.03
10 to 40 Mesh	Saws	13.40		
	Shaker	40.90		
	Rotary	1.77		
	Total	56.07	1.32	31.69
Thru 40 Mesh	Saws	2.65		
	Shaker	6.34		
	Rotary	1.45		
	Total	10.44	.24	5.89
Grand Total		177.00	4.19	100.00

ARMOUR AND THE MERCHANT MARINE.

BY PHILIP C. HUNTLY.

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Soon after the entry into the war, the federal government, acting thru its newly organized agency, the United States Shipbuilding Board, took up the question of building a large number of ships. Private shipbuilding companies were urged to exert all their energies to build ships as rapidly as possible. The question of obtaining men to operate the new ships, however. was not considered. But later some one asked, "If we build the ships, how will we get the sailormen?"

Their question was thought over by a number of men, but more especially by Mr. Henry Howard, of Boston, who is a practical man who has made the science of the sea a study—especially the Northern Atlantic coast—and he thought that if his plan would work there it must work elsewhere on the coast, and on the Great Lakes if need be.

Mr. Howard worked on his scheme for some time until he thought it complete. He then went down to Washington to put it before Mr. Denman, chairman of the Shipping Board, and Mr. John M. Donald, also of the Board, to whom the problem of recruiting had been entrusted. These men accepted Mr. Howard's plan as outlined at that time.

This plan was to establish schools along the Atlantic coast from Maine to Norfolk, Va., and if necessary to go farther south on the Atlantic and also to the Pacific coast and the Great Lakes. But there were many details to be worked out in this scheme, and many of the old rules had to be changed.

Up to this time it was necessary for anyone to have three year's experience in the engine room of a steam boat before he would be permitted to take an examination for license as an engineer. All concerned realized that if the required number of men were to be recruited for this branch of the service, it would be necessary to change the rules so as to take in men other than those who had the three year's service heretofore required.

Therefore the present rules and regulations were adopted in June. The new rules allow men who have been stationery engineers, locomotive engineers, or machinists engaged in the construction or repair of marine, stationary, or locomotive engines, to take the examination for the position of "second assistant engineer," providing they had had six months' service in the engine department of ocean or coast-wise steam vessels. A graduate from a duly recognized school of technology may take the examination for second assistant engineer if he has had three months' training in the engine department of an ocean or coast-wise steam vessel.

For third assistant engineer, the time limit was changed so that firemen with three years' experience, oilers with two years' experience, and journeymen machinists who have been engaged in the construction or repair of marine steam engines, are permitted to take the required examination.

Many other changes were made in order to take care of the navigators, chief engineers, and first assistant engineers.

The selection of schools in which to train these men before taking examination, and the length of the course, were very important questions to be considered. Professor E. F. Miller, professor of mechanical engineering at Mass. Institute of Technology, was selected as chief instructor. The schools selected were Mass. Institute of Technology, Boston, Mass.; Armour Institute of Technology, Chicago, Ill.; Steven's Institute, Hoboken, New Jersey; Case School of Applied Science, Cleveland, Ohio; Tulane University, New Orleans, La.; University of Washington, Seattle, Wash.; and John Hopkins University, Baltimore, Md. The requirements for enrollment in the course as outlined by the Shipping Board were to be passed upon by the local steam boat inspectors; and the schools were to admit candidates to a course to be extended over a period of four weeks.

The schools were notified of this arrangement June 20, and at the same time were told that they would be expected to open courses July 2. This left less than two weeks in which to prepare for the work. Professor G. F. Gebhardt, professor of mechanical engineering, was placed in direct charge of all work at Armour; but was soon called west and the work was turned over to assistant professors Peebles, Libby, and Huntly.

As soon as the board decided to carry out the Howard plan of training, notices were published in the daily papers stating that government engineering courses would be given free at the schools designated. As a result, applications by letter, telephone, and personal interview came in very rapidly from men of almost every occupation—engineers, oilers , firemen, machinists, salesmen, clerks, missionaries, and electricans. All were sure they were the type of men whom the board should chose to man the merchant marine. Many were very much disappointed when told that previous experience in the engine room was necessary. Many carried their claims to the Federal Inspector, but it took only a short time to convince them that they were not eligible.

The question of how best to give the work so the men could understand and retain as much as possible was an important one. The men were being admitted to the course by the Federal Inspector and would be required to pass their license examination before the same officer. It was therefore necessary that the work be as thorough and practical as possible.

The only requirements were that the men had had the necessary time in the engine room of a steamboat or power plant, as the case might be, that they could read and write, and that they knew the simpler rules of arithmetic. Most of the men when asked how much schooling they had had, would reply, "Now if you are going to teach me some of that algebra stuff, I quit now." Which some of them did.

It was decided that the best way to give the work, so that the men could absorb enough in the allotted time to pass the examination, was to make the course as practical as possible, and to systematize the work so that everything could be covered.

The work as outlined included the care, construction, and management of boilers and engines, the use of the indicator and planimeter, figuring horsepower from indicator cards, valve setting, condensers, evaporators, treatment of salt water, arithmetic as applied to their work, propellers, refrigeration, duties of an engineer, and many other minor things that came up during the course. When it is remembered that all of the work had to be covered in 4 weeks and also that the men taking the course were anything but prepared, any one can imagine what kind of a proposition an instructor had to handle.

It was decided to do most of the work in the lecture room, and the remainder in the laboratory where the practical solutions of the problems were explained.

With all arrangements as near completion as possible, our first class began July 2nd, at which time 14 men reported, this number increasing to 37 before the expiration of the registration period.

The first course ended Aug. 2nd, at which time the men began to take the examination. All who took the examination passed easily, some receiving Chief Engineer's licenses, others, 1st, 2nd, and 3rd assistants' tickets.

Before the July course ended, the Shipping Board wired instructions to give another course during the month of August, as a number of applications had been received too late for the July course.

Accordingly, the second course began July 30th with an enrollment of 21 men, which number was raised to 36 before the course was finished Aug. 25th. No man from this class taking the subsequent examination failed to pass it.

When the second course was finished Aug. 25th, we thought that teaching marine engineering was a thing of the past, but were mistaken. A wire was received from Prof. Miller telling us to continue the courses until Dec. 31st, and if need be, longer.

After a recess of two weeks, the third course began September 10th, with 35 men enrolled. This course ended October 6th.

The fourth course, which is going on at the present time, began October 8th; about 15 men will take this course. Our next course (fifth course) will begin November and the sixth course December 3rd.

At the present time it has not been decided whether the school will be carried on after the first of the year, but indications are that it will, as the need of men as licensed engineers, is very great at this time.

We are anticipating a large class during December and January, as the Lake boats will be tied up by that time; and the oilers, wipers, watertenders, and firemen, who wish to get licenses, will take the course before taking the examination. A number of Lake engineers have licenses, good only on lake, bay or sound. These men want their licenses to include salt water, and by taking the course can get ocean added, and also a raise in grade of license.

Armour Institute of Technology ranks with the best and ahead of most of the other schools in the number of men, and we hope to keep the enrollment, in the future, as high as possible. Some of the other schools have had only three courses, some only two, while we are on our fourth course.

Reports from the Federal Inspectors, state that the men are getting the kind of training that they need.

We have been aided in this work by Mr. Nicholas, the local Steamboat Inspector; Mr. Rivers, Mr. McNiel, Collector of Customs, and Mr. McCreary, Assistant Collector of Customs. Thru the assistance of these men, we were able to take thirty-five men for a day's trip on the Lake, aboard the Theodore Roosevelt. There the men were shown exactly how the theoretical was applied.

After the men receive their licenses, most of them have been placed on the Lakes or the ocean, and when placed do not forget to send a card or drop a line to tell us how they are getting along. They also tell us how they appreciate what we did for them; below are samples of some of their letters.

"Regards to all, will send you card from England."—MacDonald.

"Have just arrived in Colon, best regards to all."—Tomberg.

"Thanks for your kindness, will ship this week for France."—Butler.

"Many thanks to you, Professor Peebles and Libby, am chief engineer on boat leaving for France soon."—DeLude.

"We are on the 'Willehad,' German interned boat, leave for Russia soon, many thanks."—O'Donnell, Flint, and Nichols.

And many other such letters are received.

The engineering crew, with the exception of chief-engineer, for the new boat, "War Banner," built at South Chicago, were sent from our school. First Assistant N. T. Coor, Second Assistant O. E. Gille and Third Assistant J. A. Smith; besides these men, three men who needed engine room experience, were put on as oilers.

The Shipbuilding Board is trying at present to place all men who finish our school, on the boats built in this district. Our present instructions are to continue the school until January 1st, but indications are that it will be carried on thruout the year.

UNDERWRITERS' LABORATORIES

METHOD OF INSPECTION AND CHECKING AT FACTORIES

BY H. G. UFER.*

The Underwriters' Laboratories, established and maintained by the National Board of Fire Underwriters, operating under the direction of the "National Fire Protection Association," has been engaged in the examination, testing, and inspection of fire appliances for the past twenty years.

There are at present about four hundred inspectors, in the United States, Canada and England, engaged in the actual inspections at factories and in the labeling of devices coming under this supervision. This estimate does not include the engineering staff at the principal testing station at Chicago, nor that of the branch laboratory at New York.

A manufacturer of a device having a bearing on the fire hazard, or on the prevention of accidents, submits samples of the article which he manufactures to the Underwriters' Laboratories for test and examination by its engineers. They prepare a complete report as to their findings, making recommendations as to changes necessary to bring the device up to our standard specifications, if it is found sub-standard in any way.

The report, if a favorable one, is submitted to the Laboratories' councils for review and recommennation.

When the report has received the endorsement of the councils, the manufacturer is listed as equipped to provide standard material, and this information is promulgated among inspection authorities and all others interested, by means of card files and printed lists.

There are three of these couniils who review the reports rendered, namely; the fire council, the electrical council, and the casualty council, each made up of inspectors and engineers eminent in their professions and representing all sections of the United

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*With Underwriters' Laboratories.

States, Canada and a variety of interests. Two of the most important bureaus of the Federal government have engineers that are among the council members. Some twenty of the larger municipalities, including Chicago and New York, are also represented.

The commissioner of labor and industry in one of the states is a member of the casualty council, as is also the head of the factory inspection department of another state.

After the report has been voted upon favorably, the engineers of the Underwriters' Laboratories prepare a complete factory inspection procedure which covers every detail of construction, and the tests to be made of the finished article, which report is used by the inspectors who are engaged in the inspection work at the factories.

When a manufacturer has been listed as a maker of standard appliances, the Laboratories undertake to put into operation a system for keeping the institution provided with information concerning the quality and service record of that part of the factory output which is shipped from day to day and which is to be sold as complying with the Underwriters' Laboratories requirements. The system of follow up usually applied, is the service of inspections at factories and labeling.

When devices, being inspected, are found by the inspector to conform in every detail to the report covering the device, labels are authorized as evidence of goods being up to the standard specifications as outlined.

This label may be in the form of a metal plate, serially numbered, attached to each device, a gummed label, or the manufacturer may be licensed to stamp upon each device, "Und. Lab. inspected," this procedure being termed die labeling.

As a further check upon inspected and labeled devices, inspectors are instructed to send to the head office at Chicago, samples of the finished product, and materials entering into the construction of the device, at regular specified intervals, for check tests at the Laboratories.

An additional check on standard goods is obtained as follows: Labeled or tested devices are purchased on the open market, and are sent to the Chicago office for examination and test. This serves to countercheck the efficiency of the factory inspection work and to determine the service value of the product. The inspectors are furnished with report forms on which they report the results of examinations and tests made at each factory inspection. A report is made out for each factory inspected and is forwarded to the Chicago office for review.

Experience has shown that Underwriters' Laboratories label service is in every way superior, first, for the purpose of bringing to the consumer the article he desires, second, for the purpose of placing competition between manufacturers beyond the point where the deterioration in the quality of the output is made necessary, and third, for the protection of the Laboratories and the organizations co-operating with them, which are giving substantial recognition to efficient fire protection appliances.

It is also shown that an inspection and checking system of this nature can be efficiently operated under the Laboratories direction without calling upon the manufacturer to give undue publicity to his manufacturing process or subject him to any embarrassment or annoyance.

Label service is operated thru branch offices under the direction of the Chicago office of the Laboratories. There are branch offices in the principal cities and towns in the United States, Canada, and in London, England. Label service is at the present time being operated for about 150 separate industries, having an output of about 80,000,000 units per year in 1500 factories.

BRIEF REVIEW OF YEAR 1916

At

UNDERWRITERS' LABORATORIES.

The steadily increasing demands upon the facilities of Underwriters' Laboratories for service in the endeavor to lessen the fire loss and reduce the accident hazard, evidence the growing appreciation of this organization's work. The following brief outline indicates the trend of the work carried on by the Laboratories during 1916 and mention is here made of some of the more important developments. This will serve to indicate the wide scope covered by the Laboratories' services.

Several standards covering the construction and performance in tests of devices have been issued during the year.

In meeting the multiplying requests for service, the Laboratories in co-operation with the industry have evolved a new plan whereby the name of the Laboratories and the word "Inspected" or some suitable abbreviation, is to be directly applied on the article as a part of the manufacturing process.

The services provided are :(a) Inspections at factories with examination and tests of samples of newly assembled material and material in stock. (b) Counter-check tests of samples of labeled goods obtained in the market. (c) Field follow-up tests of samples secured through the co-operation of inspection authorities and users, providing for service value determinations of labeled products. (d) Summaries and schedules of results of tests made, and comparative demerits awarded individual manufacturers employing the Label Service and industries as a whole.

The Laboratories' service of inspections at factories, whereby goods found to be standard bear an inspection manifest or label, has been held back from many lines because of the expense of applying a label of the usual type. Package labeling, while in effect for a number of appliances, has not, by practical trial, been proved to be the correct solution. Advantages secured through the new labeling plan are—the savings effected in cost of labels, and the inspection symbol will be permanent, thus no claim can be made that sub-standard appliances were actually labeled at any time and that the label has been lost.

Inspection service at factories and labeling under both the old and new plans is now in operation in some twelve hundred manufacturing plants.

The work of the electrical department is conducted partly at the principal office and testing station in Chicago and partly at the testing station maintained in connection with the New York office. The New York Station is provided with all the test equipment, instruments and apparatus for electrical tests as employed at Chicago and the work is now about equally divided between the two stations. Mention should be made of check tests at two factories by the New York Station on very large orders of fire alarm cable to be used in rehabilitating the New York fire alarm system. These tests are being made at the request of the New York Board of Fire Underwriters and supplement the city test.

During the year the Laboratories have co-operated actively with the manufacturers of electrical fittings and supplies by the establishment of industry conferences, composed of appointed representatives of the manufacturers and the engineers of the electrical department of the Laboratories and these conferences have, in turn, reported to the various sections of the Associated Manufacturers of Electrical Supplies, for the purpose of formulating and recognizing standards of design and construction affecting electrical materials and appliances. Such standards as well as several covering other devices, not electrical, have been issued during the year.

The column testing apparatus, begun in 1915, is nearing completion and in all probability will be in readiness for preliminary tests early in 1917. Built-up steel columns used in modern buildings can with this apparatus be tested under actual conflagration conditions and under a maximum load, if need be, of 500,000 pounds.

Progress has been made in standardization of tests designed to furnish information of fire doors as to strength, durability and accuracy of workmanship. Advances for the year in door manufacture seem to have been confined to improvements in design and manufacture of types already found efficient when exposed to high temperatures. With rolling fire doors, the tendency has been towards the improvement of operating mechanisms with the idea of facilitating manual operation and refining the details involved in automatic operation. Door locking and closing mechanisms have received considerable attention and wire rope and various types of chains for such devices have been investigated.

During the year the standard for roof coverings has been revised, reducing the number of classes into which roofings were divided, frox six to three. Since 1915, tests and reports have been made upon a large number of roof coverings of various kinds, including coverings which complied with the requirements of the three classes. In this connection a standard for asphalt rag felt prepared roofings and shingles has been prepared in conjunction with a committee representing the manufacturers in the industry, and the Laboratories are now inspecting and labeling the product of some 30 odd manufacturers of this class of material. Roofing apparatus and equipment have been standardized and tests can be made on all kinds and classes of roofing.

Gypsum blocks for use in room and corridor partitions have been investigated with a view to extending the classification of this material to cover its use for other purposes. Hollow tile walls are receiving attention to determine if they are suitable for use as bearing walls and fire walls.

In gas and oil appliances the three principle classes of materials which have received attention have been first aid fire extinguishers, containers for hazardous liquids and acetylene apparatus for welding and lighting. New types of extinguishers are being examined and listed. New types of discharge devices, particularly such as make the measurement of liquid visible to the consumer are frequently being presented and the problem of rapidly handling hazardous liquids with safety is not being neglected. Excellent co-operation from manufacturers have resulted in progress in standardization of rules governing the building of welding apparatus.

The new hydraulic laboratory has proven its worth in facilitating the work upon hydraulic devices undergoing test, and additional test apparatus is being added from time to time as needed. Some 1,300 sprinklers have been semoved from 200 different equipments in the field and examined to determine the reliability of the remaining sprinklers in these plants. This work is increasing and is becoming more important owing to the larger number of aging installations each year. Work has been started on tabulations of the test results of these field samples to ascertain the safe average life of automatic sprinklers in various occupancies, information regarding sprinklers from tanneries, bleacheries and dye-houses being of special interest. It is intended to gradually broaden this work until acrurate data is at hand defining the period of reliability of sprinklers. Test work on experimental samples of sprinklers and other devices used in sprinkler equipments has greatly increased.

The casualty department has had submitted for review 24 different devices, nearly half of which were automobile locks. Other kinds of materials or appliances presented were; anti-slip treads, elevator safety devices, portable fire escapes, printing press guards, stair guards, window cleaner's belts, materials for the construction of guards, guards for machinery, safety flanges for grinding wheels, ladder feet and step ladders. One product of special interest is a new glass product which is essentially a celluloid glass sandwich, being constructed of a sheet of celluloid between pieces of glass and designed to reduce accidents due to flying particles of broken glass in automobile, street car and railroad accidents. The group of automobile locking devices intended to secure automobiles against theft offer a variety of methods, among which may be mentioned, locking of the gasoline supply, both in the supply line and the intake manifold; locking of the ignition circuit, in some cases separately and in others in conjunction with gasoline locking devices; locking of the steering wheel disengaged from the steering post; short circuiting the high tension wiring and other methods.

Materials for the construction of machinery guards have come before the Laboratories in the form of both expanded and perforated metals, tests being made to bring out their values in the construction of guards. Of valued interest is the testing of safety flanges for guarding wheels, which tests are now under way, and in which endeavor is made to measure the holding power of flanges, such as are used with tapered wheels, to determine the probability of the escape of segments of a wheel which might be accidentally broken during operation. These tests should be productive of valuable results and are of special interest to makers of grinding machinery.

The label service and other methods of supervision are being extended to the new industries as well as being continued and broadened in previously established lines. Standard test methods are being employed, test apparatus is being improved, and this department expects a busy year in 1917.

Besides work in the chemical department on fire hose and hose couplings, chemical extinguisher and gasolene hose, insulated wire and cable, rigid conduit, matches, stationary foam extinguishers, oil tank vents, hazardous liquids, and various proprietary articles, investigations in the field as to the hazard of plants manufacturing phenol, dyes and cotton seed products were conducted, and an investigation of the conditions having to do with the safe storage of oxygen under pressure was begun; research work on braids of insulated wire was carried on as a basis for forming a specification; specifications for rubber discs used on alarm and dry pipe valves were formulated; work in determining the characteristics of several bronzes and copper alloys was begun; and research work to obtain a suitable accelerated life test for rubber used in the manufacture of insulated wire is in progress.

Friends of Underwriters' Laboratories have felt that advantage should be taken of all proper means available for keeping insurance people, and the public as well, informed concerning the work of the institution. In line with this, the practice of providing moving pictures of parts of the work was undertaken a little over a year ago. These have been furnished to insurance organizations, state and municipal officials, credit men, churches, schools, chambers of commerce, city clubs, rotary clubs and various other classes of organizations and interests for projection at meetings and conventions in cities and towns in more than half of the states and in Canada. Whenever the usual routine of the Laboratories' activities has made it convenient to do so, a lecturer has been provided along with the pictures. This has been the case perhaps two-thirds of the times when the films have been shown. These pictures are being revised and greatly extended at this time, with the addition of comprehensive explanatory titles, and here and there, of scenes of a popular, human interest sort. They will continue to be available for projection where they can be effectively used.

There are about 130 persons on the staff of the Laboratories at Chicago now. Branch offices and branch testing stations employ between 350 and 400 persons.

Procedure Followed in Submitting Appliance to Underwriters' Laboratories.

Inquiry is often made as to how a manufacturer may submit a device to the Underwriters' Laboratories, and what the procedure is after an application is received. The following brief statement may, therefore, be of interest to manufacturers, inspectors, or others to whom such inquiries may be addressed.

The submittor may address either the Chicago or the New York office of the Laboratories and when doing so it is desirable that he furnish a fairly complete description of his device, so that its character, purpose, size, rating and similar items may be understood. Such information makes it possible for the Laboratories to classify the appliance and determine at least in a general way the probable nature and extent of the necessary examinations and tests.

The submittor is then furnished with an application blank which tells him the preliminary fee to be paid, and he is advised that the total cost will not exceed a certain sum, which is stated. The amounts of these fees vary with the size and nature of the device and the amount of investigation and test which experience has shown will be required for a device of the class.

A pamphlet fully describing the organization, purpose and methods of Underwriters' Laboratories is sent to the applicant. Full information is also given as to the character and number of samples of the appliance required, these to be sent to Chicago or to New York as the case may be.

On receipt of the application, preliminary fee and samples, the investigation and tests are begun at as early a date as is compatible with other work already in progress.

On request, the details of the device, the submittor's claims for it and the tests proposed, will be discussed with the submittor either by correspondence or in an interview, and an appointment made for him to witness the tests if he desires to do so.

At the conclusion of the work, if the results are such as to lead to a recommendation for listing as "Standard," a report to the Laboratories' Councsil is prepared and issued and the device is listed as soon as the returns from the Council are received, and copy of the report is then sent to the submittor. For some of the more completely standardized lines of electrical wares such a report is not required.

The charges for the work are billed to the submittor when the tests and report are completed, credit being of course given for the preliminary fee previously paid.

In the event that the results of examination and tests are such that recommendation for listing cannot be made, a detailed report is made to the submittor in writing giving the results of tests and the criticisms of the device. With the payment of the bill, then presented, the investigation is concluded until such time as the manufacturer desires to submit improved samples.

Only devices which are in commercial production and whose actual manufacture is known are susceptible of listing as standard, but the Laboratories are prepared to receive, examine and test devices in the model stage, and to render to the submittor only, a report for his information and guidance in their future development.

Among the organizations visiting the Laboratories during the past year are the American Institute of Architects, the Western Association of Electrical Inspectors, the Cement Institute and the National Electric Light Association. Factory inspection departments of Missouri, Iowa, Indiana, Kansas and Nebraska, and the departments of the state fire marshals of Minnesota, Ohio and Indiana have called on tours of inspection. Classes of engineering students at the following schools made the Laboratories an objective point on inspection trips: Chicago Central Station Institute, University of Misconsin, University of Missouri, University of Illinois, Armour Institute, Coyne National Trade Schools and Valparaiso University.

NOTE:—In the next issue of the ARMOUR ENGINEER will appear an article explaining the new column testing machine which was recently installed in the Underwriters' Laboratories.

THE POSITION OF THE ENGINEER IN SOCIETY.

BY C. T. McDONALD.*

Being a director of the forces at work in the great industrial activities which engage mankind at this age, the engineer is seldom inclined to survey the achievements of men in other fields of labor, in order that he may determine the position his accomplishments occupy in the advancement of the human family. He is, as a general rule, too much engaged with the complex problems that arise in his daily labors, to reflect on the part he has actually played in the present day conditions of society, or, on what, in the natural course of development, may be expected of him in the future.

More and more it is becoming apparent to the engineer himself, as well as to the captains of industry and even to the general public, that continued success of any constructive or creative enterprise is dependent very largely upon the technical skill brought to play in its administration and operation. The age of the "Rule of Thumb" has passed; not even flashes of unguided inventive genius can shield an enterprise against continued assault from without or decay from within.. The engineer; the man who plans, designs, and directs, in accordance with physical laws within the limitations of conditions, dominates our entire industrial system.. Whether he is the cause of, or the result of, the present unparalleled commercial activity is a matter of little moment.

The advent of steel, steam locomotion, electricity and new chemical processes, has caused the industrial world to develop with astounding rapidity; and in order to meet the demand thus created for trained men, everywhere in the civilized world a new form of education has sprung up, and a new profession has taken its place with the time honored professions of Law and Medicine. In every mine, in every manufacturing plant, in every transportation system, and in every municipality, movements in a forward direction or in untried fields, await the direction of the trained mind that embraces in its vision the physical laws involved, and the accumulated experience of others in similar undertakings. Without this guiding influence success is not impossible; but the probability of failure is very much increased.

The profession of Engineering, strictly speaking, did not come into existence until about fifty or sixty years ago. A few technical schools had sprung up in Europe in the latter part of the eighteenth century, and in this country in the early part of the last century, for the purpose of training students primarily in military engineering; but schools to train students in the industrial arts are a recent product of our civilization. Engineering Schools began to take their place in the Universities only within the last half century. Today there are a hundred or more such institutions in this country alone, turning out nearly as many graduates of engineering courses as are produced by all the other professional schools combined. No University now is considered adequate to the needs of the times, that does not provide some training in an engineering way. To speculate upon the influence on society of the out-pouring of these self-reliant technically trained specialists, and of the rapidly growing popularity of this and kindred forms of education, is a theme of engrossing interest and possibly fruitful of some good to those that have to do with the education of the future engineer.

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*Class of 1904. President, Multi Refillable Fuse Co.

There is no period of history more brilliant than that in which are recorded the efforts of the Scientist and his co-laborer, the Engineer, during the past 100 years. The Scientist uncovered and codified new physical laws while the Engineer applied them in swift succession to the benefit of mankind. The result has been that now even the man of humble means may enjoy comforts and luxuries that would have been the envy of medieval princes. It has been pre-eminently an age of mechanical achievements, and across the foreground of the times, in bold relief, stands the master mind, the directing force, the man who knows nature's unchanging laws,—the Engineer. This is no egotistic phrasing; it is an analytic fact. Other men, no doubt, will come to challenge his place and perhaps to usurp his influence on the human race. The question may be fittingly asked, has not the zenith been reached, and a mightier man of human affairs be growing in our midst under the cover of political and social readjustment? Perhaps, however, the engineer, who weighs all things on the scales of natural laws, may come to embrace in his vision the complex rules governing human society, and by applying engineering methods there, prove himself a still greater benefactor of the human race.

It is but natural that the engineer, when viewing the achievements of the past century, and seeing the transition of the major part of the human family from the crude and woeful conditions of living, to the modern forms of housing and comfort, as well as the elimination of the grosser and severer hardships of life, should arrive at a favorable impression of his contributions to human advancement. The young engineer on leaving the University or School of Technology may be thoroughly imbued with the notion that he is of that class of men that has given to mankind most of the things worth while in life, and that to him and his co-laborers is given the task of making life run sweeter and easier for all the peoples of the earth. In justice he may say that from him must come the utilization of newly discovered laws of nature for human comfort and pleasure.

Viewed from the commercial standpoint the engineer has no peer; he stands the Colossus of all ages; but it will not be in the busy marts of commerce, or among the hives of industry, that the judgment of mankind will be formulated as to the correct station the engineer should occupy among the benefactors of the human family. Only when this man's work is viewed in comparison with that of others, can his position be determined.

If this age has, in the field of Mechanical Arts, outstripped, in less than a hundred years, the accumulated efforts of all past ages, it has fallen short in other fields of human endeavor. It has not greatly advanced in the art of government over the age directly before it—an age that saw the transferrence of the power of government from the hands of a privileged few to the hands of the people, and which made their will law,—and the voice of the peasant more powerful in the parliaments of men, than the dictums of kings.

The enunciation of the law of thermodynamics was a great step forward in human progress. Faraday's law of Electromagnetism heralded the birth of an industry now as great as the world's total commerce of olden times. These developments have had a wide and lasting influence on the human family. But may not the law giver point with equal pride to great documents of human rights like the Magna Charta or the Declaration of Independence, and say that they mark epochs in human progress equally as far reaching in their benefits to humanity? Who would disparage Milton's or Shakespeare's contributions to the world's store of wealth, or sit in judgment on the value of the efforts of Beethoven or Handel, whose harmonies have brought joy to countless thousands of human hearts?

In one hand of the matriculated student of the Engineering School is thrust a chemical balance and a micrometer, into the other, a ruling pen and a compass; before him is pointed out the path which leads into the secrets of nature's inanimate things; to the rear is shown the structures of wood and steel raised by men of the past. To him there is no horizon to the fore, except only, the fascinating, intoxicating uncertainties beyond each solved problem. In the background he sees no glory in fields of victories won in the cause of human rights, nor hears the song of the poet, but in their place there is a keen instinct to ferret out the hidden law of nature, a determination to conquer and subdue, and a precision of judgment nearly unerring—these cold elements are the materials of which commercial success is moulded.

The engineer of tomorrow, if he is to assume and maintain the position in society that his past achievements have entitled him to, must become a man of larger sympathies and wider vision. He must rewrite his equation of real success and place therein a humanitarian factor. He must learn that in the sign of Integration representing human progress, only one of the limits is set by material aand commercial development and that the other wide flung limit, resides in human contentment and peace of all the people. He must learn to view as an equal, the law giver and the teacher, who strive to eradicate some long standing evil of society or to establish some new principle of justice. He must not disparage the work of the author who holds a mirror to the human race that it may see itself therein. He must learn to walk in the galleries of the world's master artists and see there, rare beauty and skill, rather than attempt in his view, to dissolve the paint on each canvas into its elements, to study their component parts. He must learn to stand in the great libraries of the world and know that he is but one contributor to the vast storehouse of human wealth.

A technical education never made a real engineer; it may make an efficient recorder of technical data, or a competent observer of mechanical facts, but the engineer that deserves his title must have a talent for engineering, a training and bearing that commands respect and wins leadership. He should have in his equipment a fluency and exactness of language, a logic of reasoning, and a dignity that arises from the consciousness that he possesses a general knowledge of human affairs, equal to that of the men he meets in the daily walks of life. In the engineer of tomorrow, more so than in the past, culture must find a place with calculus. Professor Burr sounded this warning in 1893 before the World's Engineer's Congress when he said; "If there is one quality which is marked by its absence in the educational and intellectual outfit in the engineer at the present time, it is that by which, in bearing and communicating, men persuade and control other men in the business life." In reviewing the Engineering Courses of study offered by the different colleges and Universities, one may mark the general absence of what might be called "Culture Study." Everything is eliminated that does not have direct application to some technical phase of engineering work. It has been estimated that with the average engineer, at least forty per cent of his work has to do directly with human beings rather than with engineering laws governing inanimate things.

The School of Technology that has courage, in the face of popular demand, to place in its courses of study, History, Literature, Economics, etc., is to be commended. If the engineer of tomorrow is to have a hand in the solution of our economic problems, as he should have, we must draw to-day more vividly the picture of Dr. Balston's parallelogram of engineering education in which is given; "One of the long sides consists of Theory, the opposite parallel side embraces Practice, and the shorter side on one parallel involves Culture, and the other Humanics. Unless the closing ends are included there would remain only two parallel lines beginning and ending nowhere."

A SATISFACTORY METHOD FOR THE DETERMINATION OF BENZENE AND TOLUENE IN CRUDE TOLUOL.

By

A. PEARSON.

The chief sources of toluol are coal tar, coal gas, and carburetted water gas. It is extracted from the tar by distillation and from the gas by means of scrubbing in petroleum oil, which is then distilled. The products of distillation in both cases is a mixture of benzene, toluene, and zylenes in varying amounts which are subsequently separated by fractional distillation and washing.

The chief use of toluol at the present time is in the manufacture of tri-nitro-toluol, a well known organic explosive.

The toluol producer seldom refines his product but sells the crude toluol, which contains considerable amounts of benzol and zylole. Consequently the buyer as well as the seller is interested in the percentages of each of the constituents in the material.

The following is a reliable method for their determination, the percentage of zylole being obtained by difference.

APPARATUS.

....

PREPARATION OF SAMPLE.

....

PROCEDURE.

....

APPARATUS FOR THE FRACTIONATION AND DISTILLATION TESTS:

The apparatus which shall be used for the determination of benzene and toluene in commercial toluol is as follows:

1—Distillation apparatus and accessories as shown on accompanying blue print No. 1.

2—18-in. gas filled thermometer (to serve as R, see blue print No. 1), graduated in 1/5° C., from 70°C. to 200°C, as made by the Taylor Instrument Companies for light oil distillation. The thermometer shall be correct to 1/5° C. when tested against a similar thermometer certified by the Bureau of Standards.

1—Chemical thermometer graduated in degree Centigrade from about 50°C. to 200°C. (to serve as Q, see blue print No. 1).

3—Glass stoppered cylinders accurately graduated in cubic centimeters up to 100 cc. (to serve as receivers M, see blue print No. 1).

1—500 cc. flat bottom glass flask with cork stopper to fit (to serve as storage flask for the 0°C.—81°C. benzene distillate).

2—250 cc. flat bottom glass flasks with cork stoppers to fit (to serve as storage flasks for the 81°C.—109°C. and the 11.5°C.—137°C. intermediate distillates).

1—1000 cc. flat bottom glass flask with cork stopper to fit (to serve as a storage flask for the 109°C.—111.5°C. toluene distillate).

1—25 cc. Pyrometer or specific gravity bottle, preferably Boot's double wall vacuum type.

1—Analytical balance with a set of accurate weights capable of weighing to .1 of a milligram (to serve for the specific gravity determinations).

1—24 inch iron stand or support with 2 suitable clamps for holding the condenser tube and the end of the condenser outlet hose. (See blue print No. 1.)

1—Distilling apparatus and accessories as shown on accompanying blue print No. 2.

1—18 inch gas filled thermometer (to serve as U, see blue print No. 2) similar to that serving as R (see blue print No. 1) as previously described.

1—50 cc. distilling flask of Jena Glass.

1—Liebig glass condenser with about 300 m.m. jacket and of the general construction as shown on blue print No. 2.

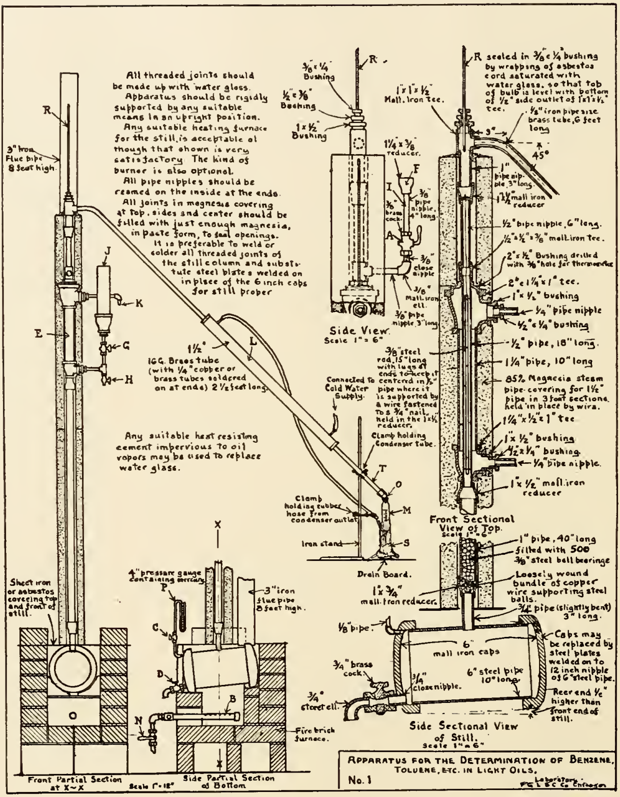
1—Burner box with asbestos top as shown for preventing superheating of vapors in distilling flask.

1—Bunsen burner V as shown in blue print No. 2.

1—25 cc. glass cylinder accurately graduated in .2 cc. up to 25 cc. (to serve as the receiving cylinder W, see blue print No. 2).

1—20 inch iron stand or support with a suitable universal clamp for holding the Liebig condenser.

In addition to the foregoing-apparatus, an accurate mercurial



All threaded joints should be made up with water glass.

Apparatus should be rigidly supported by any suitable means in an upright position.

Any suitable heating furnace for the still, is acceptable al though that shown is very satisfactory. The kind of burner is also optional.

All pipe nipples should be reamed on the inside at the ends.

All joints in magnesia covering at top, sides and center should be filled with just enough magnesia, in paste form, to seal openings.

It is preferable to weld or solder all threaded joints of the still column and substitute steel plates welded on in place of the 6 inch caps for still proper

Any suitable heat resisting cement impervious to oil vapors may be used to replace water glass.

R
3" Iron Flue pipe 8 feet high.
J
K
E
G
H
1½"
L
16G. Brass tube (with 1/4" copper or brass tubes soldered on at ends) 2 1/2 feet long.
R
3/8"×1/4" Bushing
1/2"×3/8" Bushing
1×1/2" Bushing
1"×1"×1/2" Mall. Iron Tee.
1 1/4"×3/8" reducer.
F
I
3/8" pipe nipple, 4" long.
3/8" brass cock.
A
3/8" close nipple
3/8" Mall. iron ell.
3/8" pipe nipple 3" long
Side View.
Scale 1" = 6"
R sealed in 3/8"×1/4" bushing by wrapping of asbestos cord saturated with water glass, so that top of bulb is level with bottom of 1/2" side outlet of 1"×1"×1/2" tee.
1/8" iron pipe size brass tube, 6 feet long
3"
45°
1" pipe nipple, 3" long.
1 1/4 × 1/2" mall iron reducer
1/2" pipe nipple, 6" long.
1/2"×1/2"×3/8" mall. iron tee.
2"×1/2" Bushing drilled with 3/8" hole for thermometer
2"×1 1/4"×1" tee.
1"×1/2" bushing
1/4" pipe nipple
1/2"×1/4" bushing
1/2" pipe, 18" long.
1 1/4" pipe, 10" long
85% Magnesia steam pipe-covering for 1½" pipe in 3 foot sections held in place by wire.
3/8" steel rod, 15" long with lugs at ends to keep it centered in 1/2" pipe where it is supported by a wire fastened to a 3/4" nail, held in the 1×1/2" reducer.
Connected to Cold Water Supply.
Clamp holding Condenser tube.
T
O
Clamp holding rubber hose from condenser outlet
M
Iron stand
S
Drain Board.
1 1/4"×1/2"×1" tee
1"×1/2" bushing
1/2"×1/4" bushing.
1/4" pipe nipple.
1"×1/2" mall. iron reducer
Front Sectional View of Top.
Scale 1" = 6"
1" pipe, 40" long filled with 500 3/8" steel ball bearings
Loosely wound bundle of copper wire supporting steel balls.
1"×3/4" mall. iron reducer.
3/4" pipe (slightly bent) 3" long.
1/8" pipe.
6" mall iron caps
3/4" brass cock.
3/4" close nipple.
6" steel pipe 10" long.
3/4" street ell.
Caps may be replaced by steel plates welded on to 12 inch nipple of 6" steel pipe.
Rear end 1/2" higher than front end of still.
Side Sectional View of Still.
Scale 1" = 6"
X
Sheet iron or asbestos covering top and front of still.
4" pressure gauge containing mercury
P
C
D
3" iron flue pipe 8 feet high.
B
N
O
Fire brick furnace.
X
Front Partial Section at X~X
Scale 1" = 12"
Side Partial Section of Bottom

APPARATUS FOR THE DETERMINATION OF BENZENE, TOLUENE, ETC. IN LIGHT OILS.

No. 1

Laboratory. P.G.L.&C. Co. Chicago

barometer or its equivalent should be available for observing the local barometric pressure for correcting the temperature readings at the time of the test.

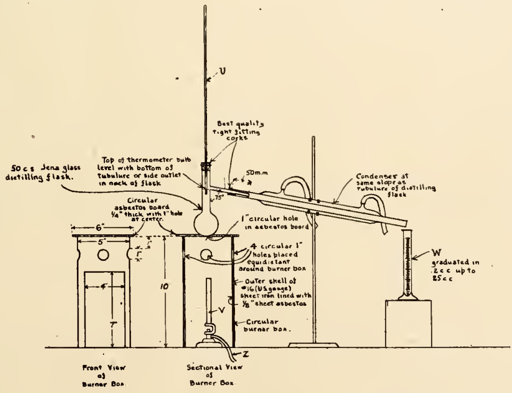
Preparation of Sample:

Exactly 1500 cc. of the commercial toluol, to be treated shall be measured out in the 1 liter and the 500 cc. flasks at a temperature of exactly 15.5°C.

The 1500 cc. sample shall then be carefully transferred and thoroughly drained into a cold 2 liter glass-stoppered separatory funnel to which shall be added 30 cc. of cold sulphuric acid of .184 specific gravity.

Taking care to avoid any loss of oil, the separatory funnel and its contents shall then be vigorously shaken for 5 minutes and the acid then allowed to settle out for at least 30 minutes, after which time the acid layer shall be very carefully drained off, taking care to remove the acid sludge only.

If the line of demarcation between the superlatent oil and the acid sludge is not clear, a few drops of water may be added to


V
Best quality tight fitting corks
50 c s Jena glass distilling flask.
Top of thermometer bulb level with bottom of tubulure or side outlet in neck of flask
50m.m
75°
Condenser at same slope as tubulure of distilling flask
Circular asbestos board 1/4" thick with 1" hole at center.
1" circular hole in asbestos board
6"
5"
1"
4"
7"
10
4 circular 1" holes placed equidistant around burner box
Outer shell of #16 (US gauge) sheet iron lined with 1/8" sheet asbestos
V
Circular burner box.
Z
W
graduated in .2 c c up to 25 c c
Front View of Burner Box
Sectional View of Burner Box

APPARATUS FOR THE DISTILLATION OF INTERMEDIATES FROM FRACTIONATION TEST OF CRUDE TOLUOL.
No. 2.

the side of the funnel and allowed to drain down in order to mark more clearly the surface of separation.

20 cc. more of cold sulphuric acid of 1.84 specific gravity shall then be added to the separatory funnel and the shaking and draining off of the acid sludge repeated as before.

If the acid settles out in the apex of the separatory funnel a clear red, the sample shall be considered sufficiently washed, but if it settles out dark and dirty, the wash with sulphuric acid shall be repeated with 20 cc. of the acid as previously specified until the acid which settles out is clear red.

20 cc. of distilled water shall then be added to the funnel, the whole shaken for 2 minutes and then allowed to settle for at least 30 minutes, after which the water shall be carefully drained off.

20 cc. of a 10% solution of sodium hydroxide shall now be added to the funnel and the whole shaken for 2 minutes and then allowed to stand for at least 30 minutes, after which the alkali solution shall be carefully drained off.

At no time during the preparation of the sample shall its temperature be allowed to exceed 25°C. This may be accomplished by allowing cold water to run over the separatory funnel frequently, particularly during the acid treatment.

To the washed sample in the 2000 cc. separatory funnel there shall be added about 5 grams of fused calcium chloride, in pieces about 4 mesh or ¼ inch. The separatory funnel shall then be well-stoppered and allowed to stand in a cool place for at least 12 hours.

The sample of clear oil shall then be considered washed and dry for the determination of the benzene and toluene by the fractionation, etc.

Before draining the dried sample of washed toluol into the still for the fractionation test, any water or calcium chloride solution shall be carefully drained off.

DETERMINATION OF BENZENE AND TOLUENE:

(a) Preliminary Procedure:

The fractionation apparatus, as shown on accompanying blue print No. 1, shall first be tested, while cold, for possible leaks by closing cocks A and D, opening gauge cock C, connecting outlet O of condenser tube T to a compressed air supply, turning on the air until gauge P shows a pressure of at least 2 inches of mercury, then closing off the air supply and noting any appreciable change in the pressure indicated by gauge P after the expiration of at least 3 minutes. If any noticeable change in the pressure indicated by the gauge P is observed by the foregoing-test, the apparatus shall not be used for the determination of benzene and toluene until all leaks have been discovered and eliminated.

The sample of commercial toluol, which is to be tested for the percentage of benzene and toluene, shall first be washed with acid, alkali and water, according to the methods given under the subheading, "Preparation of Sample."

After having been washed and dried, according to the method for the "Preparation of Sample," the remainder of the original 1500 cc. of the sample of commercial toluol taken for the determination shall be at once carefully drained into the cold and empty still through the inlet pipe I, after opening cock A and making sure that the cock D is closed. The 2 liter funnel shall finally be held in the same position with the stem in the funnel F for at least 3 minutes to permit thorough drainage of the remainer of the measured sample into the still. Immediately there shall be added, through funnel F and pipe I, about 200 cubic centimeters of a solvent naphtha which, by a previous distillation of light oil in the same apparatus, namely, that shown on blue print No. 1, distilled at a rate not greater than 3 drops per second between the corrected temperatures of 137°C. and 142°C.

The dephlegmator E shall be filled with a high boiling point mineral oil, such as wash oil, by opening cock G, closing cock H and pouring in the oil at funnel J until oil overflows at the outlet K into a pail or other suitable receptacle.

Cold water at a tempearture not to exceed 20°C. and at a rate of flow not less than 500 cc. a minute shall be made to pass through the condenser jacket L throughout the fractionation test as hereinafter described.

A 100 cc. graduated cylinder M shall be placed at the outlet of the condenser tube T, so that the lower edge at the outlet O is well within the mouth of the cylinder M, the lower part of which shall be wrapped with a loose cloth S kept wet with cold water from the outlet of the condenser as shown on blue print No. 1.

(b) Fractionation Test:

The gas supply cock N shall be turned on and the burner B lighted. The heat shall then be so regulated by the adjustment of gas flame and the flow of temperature of the oil in the dephlegmator, that the distillate is discharged at the outlet O into the 100 cc. receiving cylinder M at a rate of not greater than 3 drops per second during the middle of the cuts or corrected temperature ranges of 0 to 81° C. and 109° C. to 111.5° C. at at a rate of not greater than 1 drop in 2 seconds throughout the distillation of the intermediate coming over between the corrected temperature ranges of 81° C. to 109° C. and 111.5° C. to 137° C.

When the corrected temperature of the distilling vapors approaches 81° C. or 111.5° C., the flow or the temperature of the oil in the dephlegmator E shall be gradually regulated so that the rate, at which the distillate leaves the end of the condenser tube, is slowly reduced to less than 1 drop in 5 seconds at the time the corrected temperature of the distilling vapors reaches 81° C. or 111.5° C.

During a fractionation test, the pressure in the still as indicated by pressure gauge P, should not be allowed to exceed .3 inches of mercury, but if that pressure is exceeded, the heat shall be reduced until the pressure falls below the .3 inches of mercury before proceeding with the distillation.

The receiver M shall be removed and replaced by another similar receiver, whenever the first receiver has been filled almost to the 100 cc. mark or whenever the thermometer R, with any necessary corrections shows that the corrected temperature of the distilling vapors has just reached 81° C., 109° C. or 111.5° C. Each succeeding receiving cylinder, like the first, shall be wrapped with the cloth S kept wet by cold water. As soon as the thermometer R, with any necessary corrections, shows that the temperature of the distilling vapors has reached 137° C. the gas supply cock N shall be closed and the fractionation stopped.

The residual solvent naphtha remaining in the still shall be removed after still has become cool.

As soon as each cylinder containing distillate is removed, it and its contents shall be brought to a temperature of 15.5° C., and the volume of distillate in the cylinder then read to the nearest .5 cc. The distillate shall then be carefully poured and thoroughly drained into a glass flask (reserved for the particular fraction of distillate measured) and the flask shall then be stoppered with a tight fitting cork and kept at a temperature of about 15° C. The 100 cc. cylinder just emptied shall be used as a receiver for subsequent distillates.

In this way, each of the four distillates shall be initially received in some one or more of the three 100 cc. glass cylinders, measured therein at 15.5° C. and transferred into the proper one of the four storage flasks provided for holding the four fractions distilling over at corrected temperatures of from 0 to 81° C.; from 81°C. to 109° C.; from 109° C. to 111.5° C. and from 111.5° C. to 137° C.

Should either of the intermediate distillates which come over between the corrected temperatures of 81° C. and 109° C. or 111.5° C. and 137° C. exceed a volume of 50 cc. another fractionation test shall be run.

If neither of the intermediate distillates which come over between the corrected temperatures of 81° C. and 109° C. and between 111.5° C. and 137° C. exceeds a volume of 50 cc. they shall be given a distillation test as follows for the purpose of estimating their benzene and toluene content.

(c) Distillation Test of Intermediates:

Through a long stem funnel there shall be poured and allowed to thoroughly drain into the apparatus shown on blue print No. 2 exactly 30 cc. (or less only if necessary), measured at 15.5° C., of the intermediate distillate to be tested.

After arranging the apparatus as shown on the accompanying blue print No. 2, the burner V shall be lighted and so regulated that the distillate leaves the end of the condenser tube and falls into the receiver W at a rate not faster than 1 drop per second.

The corrected temperature, to the nearest degree, of the distilling vapors shall then be noted just as distillate collecting in the receiver W (see blue print No. 2) becomes exactly 15 cc. or 50 per cent of the intermediate distillate used for the test.

Throughout the test, the temperature of the water flowing through the condenser shall be kept at approximately 15° C.

The horizontal lines representing the corrected temperatures at which 50 per cent by volume of the intermediate distillates originally obtained between 81° C. and 109° C. and between 111.5° C. and 137° C. shall then be found on the blue prints Nos. 3 and 4, respectively, and the per cents of toluene directly beneath the intersections of the horizontal temperature lines and the respective curves shall be taken as the per centages of toluene in the respective intermediates. (See author for blue-prints.)

In the case of the intermediate distillate which originally came over between the corrected temperatures of 81° C. and 109° C. its percentage content of benzene shall be taken to be 100 minus the per cent of toluene obtained from the blue print No. 3.

(d) Specific Gravity Determination:

The benzene and toluene distillates, consisting of those which came over between the corrected temperatures of 0 to 81° C. and 109° C. to 111.5° C., respectively, shall now be brought to a temperature of 15.5° C., at which temperature the specific gravity of each distillate (referred to pure water at 15.5° C. as 1) shall be determined with an accurate 25 cc. pyrometer or specific gravity bottle or by an accurate Westphal balance to the nearest .0001.

(e) Thermometer Corrections:

The observed temperature readings of the distillation thermometer R (see blue print No. 1) and of thermometer U (see blue print No. 2) shall be corrected for error of scale graduations, if necessary, and for the effect of diminished or increased atmospheric pressure on the boiling points of benzene, toluene and xylene as follows:

For each millimeter that the local barometric pressure (in terms of ice-cold mercury) is, at the time of the test, above or below a normal barometric pressure of 760 millimeters of mercury, there shall be respectively subtracted or added at the time of the observation to the observed thermometer reading (corrected if necessary, for error of scale graduation, emergent stem. etc.) to give the corrected temperature,

.043° C. at temperatures from 80° C. to 85° C.
.045° C. at temperatures from 85° C. to 105° C.
.047° C. at temperatures from 105° C. to 115° C.
.050° C. at temperatures from 115° C. to 135° C. and
.052° C. at temperatures from 135° C. to 145° C.

(f) Final Consideration and Procedure:

The distillates collected in the original fractionation between the temperatures of 0° C. to 81° C. and between 109° C. and 111.5° C. shall be considered to consist, respectively, of pure benzene and of pure toluene with possibly small quantities of paraffine for which corrections shall be made by the method hereinafter specified.

The intermediate distillates collected between the temperatures of 81° C. and 109° C. and between 111.5° C. and 137° C. shall be considered to consist respectively, of pure benzene and of pure toluene and of pure toluene and of xylenes.

The specific gravities, at 15.5° C. (referred to pure water, at the same temperature, as 1) of the various constituents comprising the distillates obtained in the foregoing—tests shall be considered to be as follows:

For benzene	.885
For toluene	.870
For xylenes	.869

For paraffine in the benzene distillate (0° C. to 81° C.) .720.

For paraffine in the toluene distillate (109° C. to 111.5° C.) .730.

The percentages of pure benzene and of pure toluene in the original sample of commercial toluol shall be considered to be that obtained by adding together the respective percentages of benzene and toluene in terms of the original commercial toluol) as calculated for the various final distillates according to the following formulae:

Let S = The specific gravity $\frac{15.5}{15.5^\circ}$ C. of the distillate.

Let B = The percentage by volume of the benzene (0° C.—81° C.) distillate in terms of original volume of commercial toluol taken for test.

Let M = The percentage by volume of the intermediate (81° C. 109° C.) distillate in terms of original volume of commercial toluol taken for test.

Let T = The percentage by volume of the toluene (109° C. —111.5° C.) distillate in terms of original volume of commercial toluol taken for test.

Let N = The percentage by volume of the intermediate (111.5° —137° C.) distillate in terms of original volume of commercial toluol taken for test.

Let E = The percentage by volume of pure toluene in the intermediate (81°C.—109° C.) distillate in terms of that distillate.

Let F = The percentage by volume of pure toluene in the intermediate (111.5° C. —137° C.) distillate in terms of that distillate.

For the benzene (0° C. —81° C.) distillate, the

Percentage by volume of pure benzene (in terms of the original sample volume)

$$= \frac{(S. - .720)}{(.885 - .720)} B = B_1$$

For the intermediate (81° C. —109° C.) distillate, the,

Percentage by volume of pure benzene (in terms of the original sample volume) $= (100 - E)\ M = B_2$

Percentage by volume of pure toluene (in terms of the original sample volume) $= (E\ M) = T_1$

For the toluene (109° C. —111.5° C) distillate, the

Percentage by volume of pure toluene (in terms of the original sample volume)

$$= \frac{(S - .730)}{(.870 - .730)} T = T_2$$

For the intermediate (111.5° C. —137° C.) distillate, the

Percentage by volume of pure toluene (in terms of the original sample volume) $= FN = T_3$

The percentage by volume of pure benzene in the original sample of commercial toluol taken for test shall be considered to be the sum of B_1 and B_2, and the percentage by volume of pure toluene in the same sample shall be considered to be the sum of T_1, T_2 and T_3.

The respective sum total percentages for pure benzene and pure toluene shall be reported to the nearest .1 (one tenth) per cent.

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The technical press is invited to reproduce articles, or portions of same, provided proper credit is given.

The following suggestion is herewith submitted to the approval and co-operation of our contributors and subscribers.

A large number of our readers are engaged in research work. We are, therefore, often enabled to obtain articles regarding information which can not be obtained elsewhere. We know that, were demands for information relative to engineering be made known to us, we could, in many cases, supply the same in the form of articles.

Beginning with the next issue, we shall conduct a "Subscriber's Exchange" which shall be comprised of a list of subjects which have been sent in by subscribers, about which they seek information; and with them, notifications telling when the said subscribers may expect the desired article. In order that this exchange may be beneficial to all concerned, it will be essential that articles be forwarded immediately by those in possession of any information asked for in the exchange. This may be done by notifying the editors when they may expect an article relative to a particular subject.

For this number we have obtained a number of interesting editorials, and realizing their value to the student and practical engineer, we wish to bring them to your special attention.

ED.

Due to present abnormal conditions, this year has brought forth the following changes in the faculty:

Former Faculty Members in U. S. Service.

A. L. Ladd, Capt. in Engineering Corps.
Officer in charge of Engineers Depot, Newark, New Jersey.

J. J. Gilbert, 1st Lieutenant in Signal Corps.
Fort Leavenworth, Kansas.

H. H. Allport, 1st Lieutenant in Coast Artillery.

J. V. Richards, Camp Admiral, Maryland.

New Faculty Members.

K. H. Read, Instructor in Metallurgy.

N. Kimball, Fire Protection Instructor.

A. C. Williams, Instructor in Architectural Construction.

D. Studly, Instructor in Mathematics.

(Dr. Gunsaulus is under the order of the Government until the close of the war and was called upon to make addresses on the Liberty Loan so that he could not deliver the address usually given at the opening of the school year. He sends us the following extracts from the address which he would have given to the incoming Freshman class.)

There are some events that one can scarcely estimate in the dry light of which Bacon speaks, and it is with no little emotion that one approaches the task of such duties, and the acceptance of such privileges. Such a duty and such a privilege come to me in one form at the beginning of each year, and I have been reminded by one whose words to me are like laws, that perhaps this morning it may be well for us, in looking into the future, not to seek to put aside entirely those echoes that come from the past. Therefore, I might with justice repeat some of the old inspirations, and give you some of the old welcomes, to which we have been accustomed in years gone by, and I am sure that no one can stand here, as I do, without being impressed with the fact that it is distinctly a new occasion. If I were to look back over the fifteen or sixteen addresses, which it has been my honor and privilege to give here in the course of these fifteen or sixteen years, and try to avoid saying what I have said on the previous occasions, it would be a mechanical affair. But it is an affair of the spirit this morning, that reaches into one's very soul, and it has to do with the higher and more inspired life of you men. It is the distinction of this occasion to meet together and to recognize the fact that we enter, in this moment, the finest relationship among human beings, outside of those relations which God has ordained in the life of the family. After all, it is a family affair. Many of you come here for the first time to your Alma Mater. To those who are already her sons,—Is she not your blessed and noble mother; and after all, are we not coming very close in these relationships which are most tender this morning; to all things which are deepest and truest in the life of a man here and everywhere? Yes! it is my privilege to welcome you to your mother. There is no such word, in the history of education, as the word "father", placed in any such relationship to men's lives. There is no such thing in the universe that will draft into our educational life so sweetly, and with so much impressiveness, as this motherhood that belongs to the training, the scholarly influence, the spiritual culture, and, above all, the development of character which any mother likes most of all to see in her children. And it is a bright and happy moment in the history of the mother, also, to become acquainted with the possibilities of life, as she sees her new children, who so willingly and confidently place themselves in her hands for mental nourishment, and the prosperous fostering of their highest and truest selves.

It is not an ordinary sight when you see a young man come to college in the Autumn, as the old world begins to don her autumnal splendor, and see him walking down the pathway that leads to some temple of learning. It was not an ordinary sight when the Williams College boys saw that beautiful young man, Charles Cuthbert Hall coming along by the old fence, timidly, half apologetically; all the leaves of the trees were fading in gold and ruby and this young man was looking out of the spring-time in all its great contrast to the Autumn—with his own gift of a spring-time of possibility and hope and enthusiasm and joy. One of the presidents of one of our greatest Universities, who has occupied a high place in the Nation's history, told me that he never should forget the day, when, as a boy and fellow-student at Brown University, he saw coming up to the register an unknown youth, J. Lewis Diman. I remember him forty-five years after, when he stood there in Johns Hopkins University and spoke without a scrap of paper, to the delight of the most interested and well-trained audience that Washington and Baltimore could supply, leaving us with the wealth of those eight lectures on the Thirty Years' war, and I could fancy as I looked into those eyes that in after years were earlier flames of fire aglow on that morning of registration.

It was a great moment in the history of Oxford when young Gladstone came up from Eton—a man who astonished them at once with his great abilities and scholarship and a supple physical personality, which he had inherited from many generations. How much greater an hour it is when your Mother, your Alma Mater, opening her heart in her bosom of hope and faith in you, takes upon her great lap of love your youth and strength, giving beneficient eyes of sympathy, not to a young Gladstone, but to that unknown young man who has to continue self-sacrifice even to come here, who comes out of the difficulties of life with an heroic selfrespect, and who values something more than any well-groomed Gladstone can ever value them—who already has something more than any delicately housed and beautifully environed Charles Cuthbert Hall ever had. I salute in you that certain chivalric, knightly quality—a note of character, which, to begin with, is a foundation of granite, such as comes by the fires that break forth from the center of the planet, which, like all rock, means flame behind it all. Character is the greatest foundation upon which scholarship may biuld—the greatest in the world. I thank you, in the name of this institution, for the granite which you bring to us. I pray God that we may so respect the manhood that has now come to us by some self-sacrifice, and I pray God that we may so respect that manhood which you have now given to us, that, when you leave us the temple which has been reared upon those foundations of the granite may be glorious and benificent for ever.

I suppose it is true that unless a man has the feeling toward an institution that she is his mother, and that he owes to her all the duty and reverence and love which should come from a true son toward a mother, there will be little else in him except that hateful spirit of exploitation which is the bane of American life. You now forswear that spirit of getting and not giving. You have chosen a thing that in our American life, as I fear, is gradually growing less authoritative. You choose the obligation to serve. I suppose there is not a young man here who would not confess at least the temptation to go to some place of activity where his mental powers may be invested to the making of money and that alone. The very moment, my young friends, that you sacrificed the opportunity to make money now, and to exploit human life for gain, and you chose, instead the scholarly life, either for the delight of learning or the higher uses of education, preferring the mightier purpose and finer power which shall come through your training,—that moment you chose the heroic, chivalric, and knightly path. You there entered into a companionship of men and ideas, the society of men of trained faculty, men who have the aristocracy of truth in their blood and who desire to make out of life not a living, but with a living to make life worth living. You have not come here in order to treat this mother of your future power in any different manner than you should treat your own mother. She brings to you only what a mother can bring, and I have intimated that the word "father" never has been used with regard to an institution of learning. We never think of Edinburg, St. Andrews, Bologn, and Oxford as fathers. We cannot think of the Armour Institute of Technology as the father of a lot of children of the intellect—trained sons who have gone out to do the work of the world. You think of any and either of these institutions as a mother, and unless we think of her always as our mother, she will not be able to do the best for us, and we may not be able to do the best we may under any influence she supplies. I can think of a boy so heartless, so given to gold, by evil ways tearing from his own features the remembrance of his mother in his face,—I can picture one so unlike a son—that he would make what he could out of his mother, and that he should like her especially because she might provide him with the things with which he has slain his own soul. Yes! I can conceive that our American passion for getting things, and many of them things that we ought not to have, and more of them things that we have never earned;—that this passion may get control and ruin us. Our passion for driving a bargain, even in education, for making our Alma Mater yield to us some of the sordid revenues of the body, instead of the treasures of the soul is to be watched and destroyed. Certainly, unless there flows toward the mother such a love and admiration as opens the doors of the soul of the young man, there will be no room for the mother's soul—and we might as well adjourn at once! My young man, by as much as you give to this institution, by so much this institution will give to you. The doorway of your soul through which what Lincoln called the better angels of your nature walk in loyalty and faithfulness toward your Alma Mater, is the very doorway through which her best angels will come to you.

This mother comes just like any other does. She does not hope to make it pay; she does not wish the thing to be a good proposition in finance; she would disdain the idea of making things pay in the form of money. She gives you her heart, she gives you her time, patience, faith, and she will believe in you longer than anybody else in the world—man or angel. She will follow you with her mother-feeling farther than any other eyes, just because she is your mother. What you owe her you will feel only in a chivalric nature. An ignoble man never thinks he owes anything, a low and essentially brutish creature never feels anything of obligation to any one. He would sell his mother's garments to make a visible success; he would auction off his mother's heart, and put up for disposal her eyes of love, in order that he might be better off in position or wealth. There is no appeal of nobleness which will ever reach an selfish nature. The highest education of an Alma Mater is the education of a nobleness within. She says to you today: "I give you what you never can pay for, because I want to awake in you the passion and habit of giving those things which no one can pay for. I offer to you the places in this world which do not draw great salaries; the opportunities and privileges of life, which, in order that you may succeed, will mean that you must give up all, in the grandeur and loveliness of that altruism which God grant may be the glory of all our souls, as it shall be the glory of our education."

More than five hundred of your predecessors are Armour boys in khaki, and are moving toward the battle front today. They have gone where the battle rages, to keep that battle line of autocracy and absolutism from coming an inch nearer to your homes, to your Alma Mater, to your books and studies, and to the destruction of the American government. They are fighting your battle, and they ask you to be worthy of the sacrifices they are making for you. It is no time for you to give less of heroism than they give, and you can make America safe for democracy, and protect their homes, as they are now protecting your homes—each one of you—by being a true soldier for high principles, thorough devotion, and unquestionable loyalty to the ideals of your mother—the Armour Institute of Technology—who welcomes you with heart and hand today.

THE ENGINEER AND THE WAR.

The war has created an unprecedented demand for engineers. Never before has there been such a call for the technically trained man.

The value of the engineer is not confined to governmental services in this great crisis but he is a necessity in all manufacturing industries, building construction of all kinds, transportation problems, in fact every essential needed to carry on the modern operations of war.

Neither will the splendid opportunities for the engineer cease when peace is declared. The rehabilitation of Europe will present the most colossal engineering task in all history. American interests will certainly be a large factor in the physical resurrection of nations and the American engineer will have his part to perform.

The engineer who is well equipped to render adequate service has the world before him.

Following are the opinions of some of the nation's far-sighted leaders, engineers and editors, indicating the engineer's position relative to the war, and the opportunities which the future holds in store for him.—*Dean H. M. Raymond.*

WOODROW WILSON,

President of the United States.

President Wilson, in response to a direct inquiry as to what he considered the patriotic duty of educational institutions and of young men not subject to draft, replied most emphatically:

"It would, as you suggest, seriously impair American prospects of success in this war if the supply of highly trained men were unnecessarily diminished.

"I have therefore no hesitation in urging colleges and technical schools to endeavor to maintain their courses as far as possible on the usual basis. There will be many young men from these institutions who will serve in the armed forces of the country. Those who fall below the age of selective conscription and who do not enlist may feel that by pursuing their courses with earnestness and diligence they are preparing themselves for valuable service to the nation.

"I would particularly urge upon the young people who are leaving our high schools that as many of them as can do so avail themselves this year of the opportunities offered by the colleges and technical schools, to the end that the country may not lack an adequate supply of trained men and women."

NEWTON D. BAKER,

Secretary of War.

Secretary of War Baker thus summarizes conditions that are clearly indicated as certain to follow the war, and makes plain the need for more trained workers:

"Nobody knows how long this war is going to last. But we do know that when this war is over the rehabilitation of a stricken if not paralyzed civilization is going to be a long-drawn-out and uphill task, and there will be need on every hand for trained minds for trained and schooled men.

"Men should then be present in very great numbers to help bring about the great rehabilitation of industries, the reconstruction upon an earth which has been swept by all-consuming conflagration."

PHILANDER P. CLAXTON,

United States Commissioner of Education.

Commissioner Claxton knows that trained men, like soldiers, cannot be made over night, and he foresees a desperate need for trained workers in the near future:

"If the war should be long the country will need all the trained men and women it can get—many more than it has now.

"There will be men in abundance to fight in the trenches but there will be a dearth of officers, engineers, and men of scientific knowledge and skill in all the industries, in transportation, and in many other places where skill and daring are just as necessary for success as in the trenches."

CHICAGO TRIBUNE,

Called by Its Readers "The World's Greatest Newspaper."

The Chicago Tribune, which wields a tremendous influence through the Middle West, has been strenuously "doing its bit" to rouse its readers to war conditions; its picture of the engineer's present opportunities is no more than the truth:

STUDY ENGINEERING

Hardly more than half the usual number of young Americans are now enrolled as students of engineering, whereas there should be twice the usual number, for the larger part of the civilized world will have to be reconstructed after the war. Industrial plants, bridges, railroads are going to rack and ruin, even when they escape destruction. War overworks them and prevents repair. If the war lasts two years even America will have felt the strain. The demand for engineers will greatly exceed the supply.

We shall be unable to import them. When war broke out practically all the engineering schools abroad shut down, and Engineers in Europe have since been slaughtered wholesale. Instead of our relying on Europe, Europe hopes to rely on us. As things look at present it is a forlorn hope.

The Society for Promotion of Engineering Education recently went over the whole question at its meeting in Washington. One would discourage enlistment among students of engineering. Another would put those who are drafted in the engineering corps. Still another would provide government aid for young men willing to enter a technical school. The more practical suggestion and the one easiest to apply is the call for proselyting. Tell every boy of your acquaintance that engineering will be the best paid profession for at least ten years after the war. That is the truth. Make him see it. Any lad with the requisite gifts will find the technical school an open door to success and prosperity and incalculable usefulness.—Reprinted from the editorial columns of the Chicago Tribune, Aug. 2, 1917.

THE WORLD IS CALLING FOR ENGINEERS.

One of the world's better known engineers, J. A. L. Waddell of Kansas City, who has always been deeply interested in questions of engineering education, recently addressed an open letter to the profession and to the press, in which he made the following clear analysis of the situation:

"First. The larger part of the civilized world will have to be reconstructed after the war, not excluding our own great railroad system, which undoubtedly will have deteriorated on account of over-use and lack of adequate upkeep.

"Second. Such reconstruction is almost exclusively the work of engineers.

"Third. The European technical men have been killed off by thousands during the past three years; and their slaughter will not cease until the war ends. Moreover, it is more than probable that many American engineers who serve in Europe will never return to our shores, and that a large number of those who do come back will be more or less incapacitated from active professional work.

"Fourth. The technical schools of all the other warring countries than ours have practically been out of commission for three years, thus cutting down there, almost to zero, the supply of new men for the engineering profession.

"Fifth. The call to arms in this country by both volunteering and conscription it is feared will soon have reduced to about one-half the attendance at the technical schools of the United States, while instead of being halved it ought to be doubled.

"Sixth. In spite of the present paralyzation of many lines of engineering work, due to the cessation of large constructions and to the absolute lack of capital for important new projects of a peaceful character, the demand for young graduates of technical schools by the manufacturers of war supplies is so great that there is already a marked dearth of such assistance, which dearth will be more and more accentuated as the war progresses, and as the call for ships, guns, ammunition, aeroplanes, automobiles and other war paraphernalia increases.

"Seventh. Until the United States entered the war, it was almost certain that most of the reconstruction work of the world would be done by American engineers, and in any case they are sure to get a fair share of it; but it seems a shame that this country should miss such a golden opportunity as that which lies before it for securing the lion's share.

"Eighth. The capacity of the old, experienced and well-established American engineers for doing work is practically unlimited, provided that there be no shortage of young, properly-educated assistants; because most technical men of mature years have developed highly the faculty of management. On that account the average total annual amount of work engineered by such men in this country could readily be increased five fold, or, possibly even ten fold, without causing undue overstress, either physical or mental; and, consequently, the great mass of the work of world-reconstruction could emanate from the United States and be handled abroad by American engineers.

"Ninth. It is beyond question that, for the next ten years or more, engineering is everywhere going to be the most lucrative of all the professions.

"From these nine premises what is the important deduction to be drawn?

"Evidently it is that, by some means or other, we must manage not only to prevent any falling off in the attendance at our technical schools both during and directly after the war, but also greatly increase it.

"And how can this be done?

"The answer to this question is not difficult. It is as follows:

"First. By urging more young men to go to college, and by persuading their parents that it is their duty to send the boys there for the ultimate good of both themselves and the country.

"Second. By inducing all sub-freshmen who have shown any special aptitude for mathematics, mechanics or chemistry to take the technical course.

"Third. By discouraging the enlistment into the army and navy of all students in technical institutions, but, on the contrary, by encouraging them to remain and graduate, if possible. Of course, those who are drafted will have to serve; for it would manifestly, be unfair to the rest of the youths of the country to excuse a man from going to the front simply because he is a technical student.

"Fourth. By granting government aid to those youths of evident special ability in technical lines who are unable to raise the money necessary for a course of instruction.

"If these four steps are taken, the unique opportunity referred to will not be lost; and this country will then become the leader of the world in activity, effectiveness and wealth."

HALF-LOAVES.*

BY MARGARET ARMSTRONG.

(*Copyright to Harper and Brothers.*)

"My golden bowl is gone!" I cried.
    "Ah no," they said,
" 'Tis only tarnished."

"My singing bird has flown!" I sighed.
    "Ah, no," they said,
"It has not taken wing,
Poor pretty thing,
It molts and cannot sing."

I cried, "My rose is withered from the root!"
    "Not so," they said,
      "There are no roses red,
    But there are leaves along that little shoot—
    Green leaves—it is not dead."

I wept, "My lover's heart is turned from me!"
    "No, no," they said,
    "He loves you less, but let it be
    He's not untrue,
    He loves no other more than he loves you."

"This poor half-loaf is hard and dried.
I cannot eat!" I cried.
    "But it is bread,"
    They said.

*(Acknowledgment is made herewith to Harper and Brothers, publishers, and also to Miss Margaret Armstrong, the author, for their kind permission to reprint this poem, which appeared in Harper's Magazine October, 1917.)

J. OGDEN ARMOUR,
President of Armour & Company.

Mr. Armour has been investigating the war's effect upon our country's finances; and as he is president or director of companies giving employment to hundreds of thousands of men and women, his optimistic view of future working conditions is most significant:

"Whether the war lasts several months or several years, continuation of the great prosperity that has ruled in this country for two years is assured. There is an abnormal demand for everything the workers of this nation can grow or manufacture. There is work at high wages for every man and woman who wants work; the earning power of the people is restricted only by physical limitations; the buying power of the public is greater than ever before. These are certain guarantees of continued prosperity and of an ever widening scope to our business and industrial life.

"Practically all of the billions we lend our allies will be spent in this country for the products of our soil and our factories and for payment of our workers. We are the storehouse and the factory of the world now, and the more money the world can get hold of the more will be sent here, and the more that comes here, the more work and the more business will result. And in this connection, remember the government of the United States is now a buyer for war purposes and the dollars of Uncle Sam already have begun to pour forth to stores, factories, and farms to pay for the expense of mobilizing, drilling, equipping, and feeding the army and navy.

"There is not one good reason why the business of this country should not proceed in its normal course and on ever increasing lines. There is not one reason why people should fear for the future or should permit themselves to be swayed from the certainty that they are on a sound financial basis. The per capita wealth of Americans today is greater than ever before—greater than that of the people of any nation at any time in the past or in the present.

"If I were asked to give a message to the American people—to the farmers, the wage earners, the merchants, the manufacturers, and all—it would be this: Be strong in your faith that nature will reward the efforts being made to produce big crops and co-operate with our President, Woodrow Wilson, in his efforts to keep the nation composed and so organized as to most efficiently prosecute war. Be confident and live your normal lives, as far as possible. Make business proceed as usual."—Abridged from the news columns of the Chicago Tribune.

LYMAN ABBOTT.

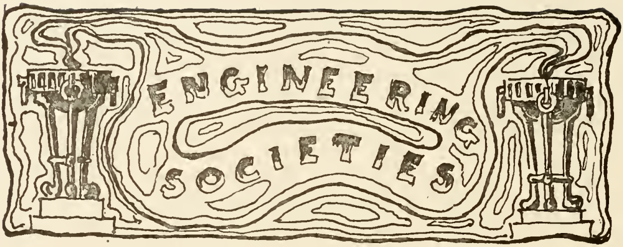
Editor-in-Chief of "The Outlook."

Dr. Abbott, one of America's deepest thinkers and most influential writers on current events, was asked to express his views on "the call of the nation"; he responded with a stirring article, in which he said:

"The country needs men now; it also needs a reserve on which it can call in the future. How many it needs now, how many it needs in the reserve, you cannot judge. The fact that you are not in the first call raises a presumption that you are needed in the reserve, for a future call; but if you are eager—go! It is better to be in the service with a satisfied ambition than at home with a restless ambition. If your heart is in the trenches, your body had better follow. But do not imagine that only those serve their country who serve it in the trenches. The country needs men to work in the munition factories, to operate the railways, to cultivate the crops, to minister to the sick in America as well as to the wounded in France; men to maintain justice and liberty abroad; men to inspire by voice and pen in pulpit and press courage and persistent resolution in the homes as well as in the fields of battle. If your country calls you to leave your home industry in order to serve abroad, go ungrudgingly. But do not forget that your country needs patriotic service here as well as there.

"Some of us are too young to go. You are at school. Think twice before you drop your preparation for life in order to enter now into life unprepared. Tomorrow will need its men and women as much as they are needed by today, and it will need them well fitted in body, mind, and spirit.

"But even if a million young men are sent into the field, there will still be left ninety-nine million Americans at home, and all of us, except the boys and girls not yet in their teens, can do their 'bit' in this world war. We can help or we can hinder."—From "The Call of the Nation," The Outlook, Aug. 1, 1917.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The war has depopulated the ranks of the senior mechanicals this year, about forty percent. There are but five senior mechanicals left, but these five, realizing the benefit of the student branch of the A. S. M. E. to its members and to the promoting of engineering in general, called the junior mechanicals together in order to reorganize. Hence, on Tuesday, October 16th, at 5:00 p. m., a meeting was held in the Engineering Rooms and as the offices of Vice-President and Treasurer were vacant, an election was held. The following men are now the officers of the Armour branch of the A. S. M. E.:

President	K. A. Taylor
Vice-President	J. A. Keeth
Secretary	V. A. Kerr
Treasurer	H. Anderson

It was decided to hold meetings every other Tuesday night at 7:30 p. m. At these meetings, the members to whom a talk has been previously assigned, will give a short talk on some engineering subject. The A. S. M. E. will make itself felt at Armour this year if the juniors go through the whole year with the same kind of "pep" as they have started in with.

The next meeting will be held October 30th, at 7:30 sharp.

V. A. Kerr.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Chairman	R. A. Newlander
Secretary	A. A. Hofgren
Treasurer	H. H. Shotwell

On Wednesday, October 10, 1917, the first meeting of the year was held. R. A. Newlander was elected Chairman to fill the vacancy left by E. A. Moore's absence from Armour this year. Prof. Freeman explained to those present the advantages of becoming a student member of the A. I. E. E.

On Thursday, October 18, 1917, the annual smoker was held in the Y. M. C. A. rooms. Mr. E. W. Grover, assistant to superintendent of Substations, Commonwealth Edison Co., talked on "The Distribution of Central Station Energy Through Substations." This included the development of power and substations of the C. E. Co. in Chicago and the present installations. Illustrating his talk by slides and discussing the present practice in power plant equipment, Mr. Grover left very good material for the student's power plant work. We are very grateful to Mr. Grover for this data as it is certain that those who heard it will profit by it.

Professor W. C. Bauer, Sc.D., of Northwestern University College of Engineering, gave an illustrated lecture on "The Electron Theory." This subject may cause wonder as to its significance to electrical engineers, but those who heard this lectu now know something definite on the subject. Prof. Bauer had his subject so well in hand and was so clear in his illustrations that one could not help but follow him. The development of this "Theory" and its application to modern practice was well set forth. We thank Prof. Bauer a great deal for his lecture and hope we may again have the pleasure of listening to him.

A. A. Hofgren.

THE CIVIL ENGINEERING SOCIETY
OF THE
ARMOUR INSTITUTE OF TECHNOLOGY.

President	J. Nitka
Vice-President	H. A. Peterson
Recording Secretary	L. Weiss
Corresponding Secretary	B. B. Cramer
Treasurer	V. M. Crown

BOARD OF DIRECTION

Faculty Member	Asso. Prof. M. B. Wells
Student Member	L. C. Bush

The first meeting of the Armour Civil Engineering Society this year, was held in the Armour Y. M. C. A. rooms Oct. 2.

The meeting was called to order by the President at 8:45 p. m. The minutes of the last meeting were read and approved.

The first duty of the evening was the initiation of four new members. The initiation, which consisted of an oral examination upon engineering subjects, fairly non-plussed the new members; but after a proper interval, their recitations were accepted, and they were received into the society as members by a unanimous vote.

The next business of the meeting called for a discussion regarding the admittance of Freshmen and Sophomores as Junior members of the Society. Professors Wells and Penn each spoke in favor of admitting the under classmen and pointed out the advantages, they, as well as the society would derive from such an arrangement. It was moved and seconded that the President appoint a committee to investigate this matter and submit a report at the following meeting. A committee of three was appointed. The meeting was adjourned at 9:45 p. m., after which refreshments and cigars were served.

The second meeting was held Tuesday, October 16th, in the engineering rooms of Chapin Hall. It was decided at this meeting that the Freshmen and Sophomores be admitted to the Society under certain conditions stated below. A Freshman may become a member of the society by paying an initiation fee of one dollar; Sophomores must pay in addition to the initiation fees dues of one dollar per year. Heretofore membership to the society had been restricted to Junior and Senior members and this new provision gives the underclass men a wonderful opportunity to derive the benefits of the society early in their career.

After the meeting Mr. L. Weiss gave an interesting talk on his experiences this summer in connection with work for the Santa Fe and Rock Island R. R. Much interesting information was presented on cross-sectioning, ballasting, bank widening, bridge surveys, and other points of interest equally instructive.

Blois B. Cramer.

THE CHEMICAL ENGINEERING SOCIETY ARMOUR INSTITUTE OF TECHNOLOGY.

President	F. R. Johnson
Vice-President	C. W. Muehlberger
Secretary	S. J. Modizkowski
Treasurer	A. Pearson

The first meeting of this Society was held September 17th, Mr. Cable officiating. The above officers with the exception of vice-president, were elected and the meeting adjourned.

October 8th, a second meeting was held and Mr. Muehlberger, representing the Juniors, was elected vice-president. A banquet was proposed, and after a discussion of the question, the president was empowered to appoint a committee to investigate the details. A number of interesting speakers have been secured for future meetings. Several student lectures are also to be given.

S. J. Modizkowski.

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	T. Trask
Vice-President	L. Kuttnauer
Secretary	R. Mann
Treasurer	C. Mintz

The first meeting of the year of the Armour Fire Protection Engineering Society was held in Machinery Hall on Thursday, October 23rd. Trask, '17, acted as temporary chairman, and an election of officers was immediately held. Trask was unanimously elected president of the society and Kuttnauer was elected vice-president in the same manner. The offices of secretary and treasurer were filled later. The meeting adjourned without transacting further business.

R. N. Mann.

ARMOUR ARCHITECTURAL SOCIETY.

Massier	Everett F. Quinn
Treasurer	William C. Wright
Secretary	Armand R. Monaco
Purchasing Agent	Stennet C. Hulburt

The name of the society has been changed this year from the "Atelier" to the "Armour Architectural Society." A smoker was held November 9th. We are planning initiation for November 20th, and have several entertainments and inspection trips in mind.

Armour Institute of Technology Library

ARMOUR INSTITUTE OF TECHNOLOGY LIBRARY SELECTED LIST OF BOOKS ADDED,

MARCH-OCTOBER, 1917.

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THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

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Former students of the Armour Institute of Technology met last May for their regular spring banquet, which was held in the gymnasium.

About 140 men answered the summons, and after enjoying a good repast, listened to some stirring talks rendered by Dean Monin and a Wisconsin lawyer named Martin Gillen.

Dean Monin's talk on patriotism was wildly cheered by the alumni. He surely dispelled any illusions as to where he stood in the great conflict by terrific "drum fire."

Martin Gillen, a lawyer and Irish, gased and bombarded us for several hours on "real inside stuff" from the "star chamber." He gave some vivid views of the chaotic conditions this country was in and the tremendous effort made by the war heads to co-ordinate the reins of business without the least interruption in one of the most difficult tasks ever besetting this country.

That the task of organization of our power for war was to be a big one is now more fully realized than it was then. We have been at war six months and not a rifle shot fired. And, by the appearance of things another six months will go by ere the rattle of rifle fire by the "boys in blue" will be heard by our enemies.

After the speeches a business meeting was held. Among other things it was decided an effort be made to have the "Tech's" former students fill out cards to be sent them giving in detail many facts concerning themselves that might prove of service in case such information was desired. These cards are to be mailed back to the Recording Secretary and kept on file. Also it is desired among other information to know of every enlisted former student—the date of enlistment, what branch of the service he is in, and the rank he holds.

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by

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and

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CENTRAL STATION SYSTEM SUB-STATIONS.

BY E. W. GROVER*

Asst. to Supt. of Substations Commonwealth Edison Co.

This article is not intended to cover the details necessary to the engineering work preliminary to the installation of apparatus, but has been prepared as a discription of the equipment actually in service in a going concern, together with such details of the methods of operation as may be necessary to give a brief idea of the operation of a large system of central station sub-stations.

A system of sub-stations is in reality highly specialized detail in the problem of distribution of electrical energy for modern stations. In plants of smaller size, electrical energy may be economically distributed to customers at reasonable distances at a voltage suitable for customers requirements, but as the plant size is increased and the amount of energy available becomes greater, a condition is generally reached where load density at the customer's voltage is not great enough to absorb the output of a large plant within an economical radius of distribution.

In the early periods of the electrical light and power industry and when systems were small, the characteristics of the electrical equipment at the generating stations were determined directly by the requirements of the customer to whom the product was delivered. Likewise the character of the service with relation to voltage regulation was determined at the central station switchboard. As central station business increased and the art developed, it became advisable to produce in as large quantities as was feasible in a given generating system, in order to utilize the higher efficiency of units of large capacity. In turn this resulted in the replacing of numbers of small plants by much larger central stations. Favorable locations for these large plants with reference to transportation and water facilities then became important, and it became necessary to locate them not at a point with reference to center of gravity of the load served, but at a location where coal, transportion facilities and ample supplies of condensing water were available. The result of this general trend of development was to gradually abolish the direct distribution from station to the customer and caused the development of sub-stations wherein the energy could be received from the generating station in a form best suited to transmission and then converted to a form most suitable to distribution to neighboring customers. At the present time the type and character of generating station equipment is, with a few special exceptions, selected on a basis of transmission requirements and it is only through the medium of suitable sub-station equipment that central station energy is adapted to customers requirements. Originally, when it was the practice of operating companies to deliver their output to customers directly from the generating station, a considerable proportion of the output was direct current and as the business and the area of direct current distribution increased, new generating stations were built to supply the demand in their immediate vicinities. It was impracticable to transmit energy at a low potential over considerable distance, due to the enormous investment required for distributing copper. The distance to which 250 volt, three wire, direct current may be economically transmitted is somewhat less than three-quarters of a mile, varying of course with the cost of copper.

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*Class of 1904.

By reason of these limitations of D. C. transmission the engineers of the operating companies were confronted with the problem of extending the system to take care of the increase of load, without at the same time having to construct numerous small and inefficient generating stations. The solution of this phase of the problem was found in the adoption of higher voltage, alternating current transmission, supplying motor generators or rotary converters located at points favorable to the distribution of load. In the conjested business districts direct current distribution had generally become so firmly established, that it was impracticable to attempt to substitute A. C. distribution. Various considerations finally led to the adoption of three phase, 25 cycle alternating current generating aparatus and the employment of large units installed in a large centrally located generating station. Rotary converters operating at 250 volts, 3 wire, were installed at convenient locations throughout the D. C. territory to take care of customers' loads and the small generating stations gradually put out of service and dismantled. Throughout the D. C. districts, the concentration of load was sufficient to warrant the continuation of D. C. distribution, but in the outlying districts, where the concentration of load was much less and to avoid the losses due to uneconomical distribution at low voltage direct current, an alternating current distribution system was devised. In general this consists of 60 cycle, three phase, four wire alternating current distribution, at about four thousand volts between phases, delivered to small neighborhood transformers from which the customers are supplied by low voltage, three wire services, usually at 230 volts.

Motor generators or frequency changers are installed as a means of converting from transmission line frequencies and potentials to those most suitable for distribution. In larger systems, where the total volume of 60 cycle load is sufficient, large capacity 60 cycle generators are installed in central stations and deliver energy at proper transmission voltages to large 60 cycle transformers in sub-stations, from which the distribution system is supplied, resulting in a considerable increase in sub-station conversion efficiency over that possible through the use of frequency changers. The sub-station system has in modern practice become an indispensable link between the generating station and the cusomer.

In large cities, where one large central station plant or a group of large plants supply electrical power needs of the population, three general classes or types of sub-station equipment are generally required as follows: 250 volt rotary converters supported by storage batteries for supplying the D. C., three volt net work usually found in the congested districts of large cities; 600 volt rotary converters, in some instances with battery auxiliaries, for supplying street and elevated railroads; and large capacity transformers or frequency changers with voltage regulation auxiliaries for supplying alternating current to districts where load densities are not as great.

As the distribution of energy to the 250 volts, three wire direct current system is an important feature of most large public service central station companies, it will be described first.

The direct current output received from sub-station units is delivered to the sub-station D. C. buses, one or more in number for each polarity of the system. Connecting to the buses through suitable switches are various feeders ranging in size from #0000 to 2,000,000 C. M., which carry the energy to connecting points on the distribution system, known as junction boxes. From these junction boxes connecting copper mains carry the current through the streets and serve as sources of supply to which customer services are directly connected.

The mains constitute what is known as a net work which is continuous throughout the D. C. distribution territory. The points of connection and size of sub-station feeders depend upon the nature and concentration of the load, and are so determined that the net work is maintained at practically a uniform potential of 115 volts between the outside conductor and neutral, or 230 volts between outside conductors. The feeders from a given sub-station are naturally of different lengths, and in order that the output may be properly distributed without causing overloads or unequal potentials in the net work, it is necessary to supply the longer or heavier loaded feeders with higher potentials than are required for the others. To maintain exactly even potentials at the end of all feeders it would be necessary to operate a separate bus or source of supply for each one, but as this would be impracticable, a close approximation is effected by operating two or three and sometimes more, sets of buses at different potentials, and then properly distributing the feeders between buses according to their individual needs. The pressures or potentials at various points in the net work are determined by the sub-station attendant either by calculation based upon the size, load, and length of the feeder, or by means of small pressure wire connecting to the feeder ends and leading back into the sub-station.

The 250 volt sub-station capacity for supplying urban D. C. districts may vary from 500 to 10,000 K. W., depending upon the density and proximity of the load. It would be only to meet very special conditions that the capacity might exceed the later figure, on account of the congestion of feeder copper necessary to distribute larger loads, and the limited difference to which energy at this voltage can be economically transmitted.

A description of an actual D. C. sub-station follows and is in general typical of average practice for this type of installation. The apparatus consists of two 1,000 K. W., two 2,000 K. W. horizontal shaft rotary converters and one 2,000 K. W. vertical shaft rotary converter. Auxiliary to the converter capacity is a storage battery installation capable of delivering 3700 K. W. throughout a period of one hour.

Each of the converter units is supplied with three phase, 9000 volt, 25 cycle current from one of several high tension lines connecting with the generating station. The high tension connections are so arranged that energy for a given rotary converter may be obtained from any one, or all, of the high tension lines. This is accomplished by installing a separate high tension bus for each unit, to which is connected, through oil break switches, a high tension line and the transfer bus. The latter is arranged to be connected to any one or all of the machine buses at will. This arrangement is provided so that no machine is dependent upon a given line for its source of supply.

The rotary converters are connected to the high tension buses through remote control oil switches. The converter transformers are generally of the three phase type, although in some of the older installations, set of three single phase transformers were used. The primary transformer coils are connected in what is known as delta, with provisions whereby different taps may be used in order to permit a slightly different ratio of transformation. It is occasionally necessary to increase or decrease the voltage of a rotary converter in a given installation beyond the limits available by ordinary methods of regulation, in order that the units may be adapted to supply unusually high or low voltage D. C. buses, such as might be necessary for supplying unusually long or heavily load feeders.

The secondary connections of the rotary converter transformers are of the type known as double star, diametrical, which provides six loads giving six phase potential relations. The middle point of the diametrical star connection is also brought out and connected through a hand operated knife blade switch to the neutral of the three wire D. C. system.

The six phase transformer secondaries are generally connected through an induction plant potential regulator, to the collector rings mounted on the shaft of the rotary. From the collector rings the current passes to equidistant points in the machine armature windings. The armature circuits of a rotary converter are practically identical with the windings of the ordinary type of multiple circuit wound, direct current generators, except that they are equipped with the A. C. collector rings and armature taps mentioned above. The output of the rotary converter passes through circuit breakers, hand controlled for small units and remote controlled from the switchboard for large units, and is delivered to the D. C. sub-station buses. From the latter the current is distributed through the D. C. net work described previously. In the later types of installations the rotary field connections are arranged so that the machine is self excited, by the connection of the fields at a point between the circuit breakers and the main armature sector switches. These armature switches are arranged so that the unit may be connected to either of two of the D. C. buses.

In order that the rotary converters may be safely operated, they are equipped with protective devices, consisting of overload relays, speed limiting devices, and in some instances reverse current relays. The overload relays are actuated from series current transformers in the high tension leads of the rotary transformer and in the case of dangerous loads cause the machine oil switch to open. All 250 volt rotary relays are set to operate at 125% overload. The speed limiting device consists of a small centrifugal switch mounted on the rotary shaft, which operates to open the D. C. circuit breakers and disconnect the machine from the D. C. system whenever the speed of the unit exceeds approximately 15% above normal. It was formerly also the practice to equip 250 volt rotary converters with reverse current relays, which would operate whenever there was a flow of current from the D. C. system toward the A. C. system in amounts exceeding about 25% of the capacity of the unit. In actual practice, it was found however, that in most cases these devices were of greater annoyance than service, in that a momentary lowering of the A. C. line potential would cause the storage batteries, which normally are floating on the buses, to discharge back through the rotaries and cause the operation of the reverse current relays, resulting in the unnecessary disconnection of many units.

Modern practice does not contemplate that the overload protective devices on power plant units are necessary to protect against small or momentary overloads but are used to protect the remainder of the system from interruption due to the effect of break downs in units themselves. Protective devices must be effective in cutting out a defective or broken down unit promptly to avoid affecting the service of other units, but should not ordinarily disconnect a unit on account of loads from external causes. The station attendant is expected to take control of cases of this kind. The A. C. overload relays are set high enough to prevent the opening of the machine switches at any overloads permissible to be carried for an appreciable length of time, but will disconnect the unit from the A. C. system in case of a short circuit within the unit or adjacent D. C. buses. The overload relays are of the inverse time limit type which operate in a length of time that is inverse through the amount of overload. There are no overload features provided on the D. C. circuit breakers.

There are several methods in common use by which the potentials of rotary converters may be regulated at will, viz: installing sufficient reactance in the transformer secondary leads and then accomplishing the regulation by varying the shunt field excitation; by installing what are known as split pull rotaries; by connecting an alternating current synchronous booster generator in series with the transformer secondary A. C. leads and varying the voltage of this unit by its field control; by connecting a boosting transformer of variable ratio, such as an induction potential regulator, in the alternating current leads of the units. The first method is applied only to railroad units where the required range of voltage regulation is not great, and where the machine is compound wound to take care of sudden fluctuations of load with corresponding D. C. variations in pressure. The variation of field strength in a rotary converter has practically no direct effect upon the potential of the unit, but does effect the power factor of the A. C. supply, causing a leading current with strong excitation and a lagging current with weak excitation. If, however, there is reactance in the A. C. circuit the effect of leading currents is to cause a rise in A. C. potential with a corresponding rise in D. C. potential, and vice versa for lagging currents. The second method of potential regulation requires the installation of a special form of rotary converter of the split pole type, in which the variation of potential is accomplished by changing the A. C. wave from a broad flat type to a narrow peaked type, resulting in a low or high D. C. pressure, as the D. C. pressure is determined by the maximum E. M. F. of the A. C. wave and not by the effective E. M. F. This control of wave form is accomplished by means of a divided field pole construction, wound so that the excitation of each division can be independently varied. The third method of regulation, using a series A. C. booster generator, has recently become commercially prominent and is in practice entirely successful. Apparatus of this type consists of a rotary converter with a 6 phase booster generator armature mounted on the same shaft with the converter armature, but with a separate field structure. The armature windings are separate for each phase and are in series with the A. C. conductors from the collector rings to the rotary armature. The potentials developed in the booster armature are in phase with, and add to or substract from the potentials delivered by the transformer, depending upon the amount and direction of excitation in the booster fields. The fourth method, using A. C. potential induction regulators, is the most common in older installations. The induction regulator is practically a transformer with its secondary winding connected in series with the rotary a. c. supply leads and with the primary winding supplied from across phases. The primary windings are mounted upon a movable core that can be rotated within certain limits, and which, by causing the primary flux to act upon certain portions of the secondary winding, causes a boosting or choking action upon the secondary series windings, depending upon the relative mechanical positions of the primary and secondary coils.

There are two forms of induction regulators commonly used in connection with rotary converters. The older type are usually 6 phase designed for use in the transformer secondary leads, and are air cooled, but, recently 3 phase high voltage regulators connected on the high tension side of a transformer were developed. The latter are usually of the oil cooled type.

Modern practice in large direct current sub-stations supplying 250 volt service, requires that all oil switches of transmission lines and machines, and also direct current circuit breakers of units, be operated by remote controlled motors or solenoids. By these devices the centralizing of all controls on a sub-station switchboard may be readily accomplished, materially increasing the safety and inconvenience of operation of large capacity installations. With present large capacities in sub-stations it is impracticable and unnecessary to carry the entire output of the machines directly to the main control switchboard, on account of the large dimensions and congestion of copper required. Therefore switchboard control panels for large units contain only small control switches, machine meters, and sometimes field switches. All heavy copper leads, buses, switches, etc., are placed in a location more or less remote from the control panels, but convenient to the distributing feeders. The switchboard panels for the machines contain two d. c. ammeters, one for each polarity, and a. c. power factor indicator and an a. c. wattmeter. The control switches for the a. c. and d. c. machine main switches, field rheostats, and potential regulators, d. c. starting circuit connections and field switches, and the synchronizer switches are also located to be visible from the control board, but the feeder switches are located generally remote from the main switchboard near the terminals of the d. c. feeder cables. The feeder panels contain the individual feeder circuit switches only, arranged so that each feeder can be connected to either of two d. c. buses. Fuses and circuit breakers are seldom provided for the d. c. feeder circuits at the sub-station end, although they are fused at the junction box in the street. The vigilance of the attendant is depended upon to open feeders in case of short circuits. The underlined principle of the practice is to prevent unnecessary interruptions of service through the blowing of fuses in the supply feeders when the actual trouble is located in the outside net work and will be eventually isolated by the blowing of fuses at the connecting points of the net work adjacent to the trouble. Trouble on the feeder cables themselves will be apparent to the attendant through the indications of feeder ammeters and defective cables will be promptly disconnected.

The high tension line terminals and buses are located so as to be ready of access but are effectually protected and guarded so as to minimize the danger of high voltage short circuits or personal contact through inadvertent action on the part of persons in the immediate vicinity. All conductors are either heavily insulated or installed in fire proof insulating compartments.

Oil switches are installed so as to be readily accessible for inspection and cleaning, and are reasonably convenient for hand operation if necessary. Disconnective blades are provided on all oil switches so that an air gap of sufficient length may be opened in series with any switch or conductor to effectually isolate it from all possible sources of high potentials. Facilities are also provided whereby any high tension switch, line, or bus may be ground to further minimize danger of personal contact with high potentials when construction or repair work is in progress. Where all transmission and distribution cables are underground no protection is necessary as against lightning.

With respect to the operation of rotary converter units, there are several methods by which they may be started and put into service, each of which has certain advantages under special conditions. 250 volt rotary converters are ordinarily started in the manner of ordinary shunt wound direct current motors, through resistance boxes. The machines are brought up to speed by this method and a synchronizer connected, in effect, between the machine a. c. leads and the a. c. bus. The potentials for the synchronizer instrument are not taken directly from the high tension conductors but are supplied from the secondaries of potential transformers whose primaries are connected to the high tension conductors through low capacity high tension fuses. The synchronizer gives a visible indication of the relative frequencies and phase relations of the rotary and line potentials by means of a rotating needle. With this instrument the operator is able to determine the exact time when the rotary converter oil switch may be safely closed. The operation of synchronizing large units, while simple in principle must be done with precision, and the connection to the machine established exactly at the proper instant, i. e. when the instrument needle points to the "in phase" position on the instrument dial. A deviation of five degrees on the instrument dial may, with the larger units, cause the transmission line to open automatically or possibly damage the unit. Should the connection be established when there is a phase displacement of 180° the result would be equivalent to a short circuit of double the machine potential.

It is advisable to provide at least one rotary in each 250 volt sub-station with facilities for starting directly with a. c. supplied from the transmission lines, to guard against the possibility of the d. c. net work becoming entirely dead following a severe case of trouble. A. C. starting facilities may be obtained through the use of one-half potential taps connected to the transformer secondary coils. With this method the starting is accomplished by connecting the rotary, with its field circuit open, to the special taps and then supplying the transformer with full line potential. The rotary will immediately start and rapidly come up to full speed at which time the field circuit may be closed. The armature a. c. leads are then transferred by a quick operation of knife blade switches to the full potential transformer leads. This method of starting while rapid is not considered good practice where the d. c. method can be used, on account of the very considerable strain on the equipment. Also at a time following an extensive interruption of d. c. service, should a considerable number of units be started simultaneously by this method, the effect upon the transmission system and the generating stations would be serious by reason of the heavy lagging currents taken while the unit is accelerating.

In order that the d. c. net work may be made less subject to interruption storage batteries are installed and kept floating on the system, i. e. connected to, but normally neither discharging or charging. Batteries may be provided also to carry peak loads, but this is not usually done except under special conditions, on account of the large investment required and the comparatively small output available as a result of that investment.

When batteries are used for "stand-by service," i. e. to secure the service against interruption, the capacity required may be about 25% of the total converting capacity, and they should be of a type that can discharge at extremely high rates and at the same time not be subject to material deterioration when used infrequently. Storage batteries successful for this class of duty are not best adapted to be frequently used in carrying peak load, on account of rapid deterioration of plates under charge and discharge conditions. Conversely a battery suitable for peak periods is generally unable to carry the high discharge rates demanded of the "standby" battery, assuming equal investments in each case.

The 250 volt system batteries are installed in two sections of about 75 cells each, one section connected to each polarity of the system with the common terminal of the two sections connected to the net work neutral thus rendering the battery available for discharging for either or both sides of the system. Of the 75 cells in each section, about 25 on the extreme positive and negative ends are connected to be used as regulating cells, or as ordinarily known, end cells. The end cells provide a means of varying the battery potentials to suit the needs of the service. From each of these end cells a connection is brought out to an end cell switch consisting of a large copper contact brush making a sliding contact between a bus bar and the individual end cell connections. This brush may be moved to any desired position through the operation of a motor which is controlled by a remote control switch on the station switchboard. There are usually two but sometimes three of these end cell switches on each end of the battery so that it may be connected and discharged on any of the sub-station d. c. buses.

As stated previously it is the general practice to keep the batteries connected to the d. c. net work at all times so that they will be available for instant service should the converting machines be shut down for any cause. While the battery is floating the individual cell potentials are maintained at 2.06 volts. This permits of a slight charging current, probably in the order of two or three amperes per battery plate and is necessary in order to maintain the battery plates in good condition. If the floating voltage is not properly maintained especially in batteries of the "standby" service type, the plates will be subjected to deterioriation through sulphating, shedding of active material, etc.

Batteries are charged in sub-stations in either one of two ways; by special d. c. booster generators or by means of rotary converters with unusually large ranges of voltage control. A considerably higher voltage is necessary for charging batteries which is not available on the standard equipment, as the charging voltage for 150 cells may run as high as 400 volts. The general procedure of charging is to connect the battery to a sufficiently high source of potential that a charging rate of approximately one-quarter of the normal one-hour discharge rate of the battery can be maintained. This rate is sustained until the cells are freely giving off gas, and the voltage required for maintaining the charging rate has been constant for a specified length of time, usually one-half an hour. Practically all central station batteries at present are of the lead plate sulphuric acid type.

All batteries are installed in especially constructed rooms, wherein every practicable precaution has been taken to prevent serious result from the action of the sulphuric acid fumes. The floors are laid with vitrified tile over special impervious paper and set in an asphaltum compound. All floor and wall corners are protected by lead flashing and all copper or other exposed metal work in the room is either lead coated or covered with a grease which is not effected by the acid. Special ventilation is provided to remove acid fumes, and lessen the probability of acid action on other sub-station equipment.

In recent years the capacities of individual converting units has increased considerably, but their dimensions for given capacities have been reduced to a remarkable degree through the adoption of inter-pole windings and relatively higher speeds. The modern 4000 K. W. rotaries are scarcely larger in floor space requirements than the 1000 K. W. rotaries of ten years ago.

That portion of sub-station equipment devoting to supplying 600 volt railway service in large cities differs considerably from the equipment used for 250 volt service. The individual units are generally larger and the sub-station is simpler in arrangement. The high tension bus and switch layout is practically identical with that for other forms of sub-stations. Greater total capacities in a given sub-station are practicable on account of the greater economical distributing radius possible through the higher distributing voltage. All large railway converters are of the six phase type, compound wound and are capable of automatically regulating output pressures within reasonable limit for this class of service. The requirements of potential regulation are not as precise for railway work as for power and lighting service, although the momentary variations are greater on account of the nature of the load. The regulation afforded by the automatic action of the series field is supplemented by hand control.

The compound windings of railway converters necessitate the installation of equalizer buses and switches, which are unnecessary in lighting stations where shunt wound machines are used.

A tendency is developing among designers of railway sub-stations of large capacity to adopt machines which do not have a rising voltage regulation characteristic with increase of load. On small isolated systems a rising characteristic is generally desirable, but on large systems where individual units are large and sub-stations are comparatively close together, a rising characteristic results in greater severity in the effect of short circuits, with correspondingly greater danger of damage to equipment. A rising characteristic also increases the tendency toward unstable operation between adjacent sub-stations, which are connected by large amounts of copper, as this condition is somewhat comparable to operating two compound machines or stations immediately adjacent to each other, without equalizing connections.

Railway sub-stations d. c. connections are simple, consisting of the d. c. machine switches and circuit breakers for connecting the machine to the bus to which all individual circuit feeders are also connected through circuit breakers and knife blade switches. The machine and feeder circuitbreakers are all equipped with overload devices and in addition, the machine breaker is also actuated by low voltage and speed limit devices. The overload breaker settings are such that the breakers open on short circuit and overloads occuring on feeders and machines. On the a. c. side of the machine, overload relays controlling the action of the machine oil switches are set to operate only in case of trouble in the machine itself. The d. c. breakers on the machine are set to open at the highest load that the machine is considered able to carry momentarily. This practice is adopted to guard against continual interruptions due to momentary heavy load swings, which are frequent in railway service. The attendant is expected to protect the machine against destruction from long continued overloads by putting additional units in the service, or by calling upon the adjacent sub-station for assistance. The low voltage devices operate to disconnect the unit from the d. c. side in the event the d. c. bus potential falls below approximately 300 volts. This protection, together with the speed limit protection is necessary in case the transmission line should become dead or short circuited, and the rotary should start to feed back into other sub-stations on the same transmission line or into a short circuit on the line. Under these conditions the rotary would attempt to operate differentially compounded resulting in the partial neutralization of the shunt field by the reverse series field. The unit would accellerate in speed causing an increase in the amount of d. c. current in the series field which would further neutralize the effect of the shunt field. This condition would become cumulative in its effect until the unit destroyed itself from excessive speed. Experience has indicated that the above sequence of events may take place within the space of a few seconds and before the attendant is able to effectively control the situation. With the speed limit and low voltage devices in proper working order, there is little chance that a disaster of this type can occur.

Storage batteries are frequently used in railway service to take care of peak load conditions, but are not generally used for "standby" work. Railway batteries are seldom equipped with end cell switches, but use a series booster generator for both charge and discharge operations. Some are arranged with automatic control on the booster generator so that the load on the station converting or generating equipment is maintained practically constant and the battery discharges on all heavy load swings, and charges in the intervals between swings. There are many combinations of railway sub-stations and battery equipment that can be made to meet special and peculiar conditions of service.

A number of years ago, several companies operating railway rotary converting units of 1000 K. W. and 2000 K. W. capacity, were having considerable trouble due to the machines arching from commutators and armature conductors to the grounded structure of the unit. After considerable investigation and experimenting, it was concluded that the trouble was due to high voltage surges in the d. c. and low tension a. c. conductors of the machine. These surges were possibly caused when the machine circuit breakers opened under conditions of extremely heavy load or short circuit. The instantaneous collapsing of the lines of magnetic force surrounding the heavily loaded conductors, together with some possible capacity effects in the circuit, were believed to have caused a momentary high potential which discharged to ground at the most favorable point. The difficulty was apparently overcome by installing aluminum cell lighting arrestors connected between the positive and negative leads of the machine. At ordinary potentials, these cells permit a very slight of amount of current to flow, but an unusual increase of potential across their terminals, causes them to act in a measure. as safety valves and permit sufficient current to flow to keep the potential on the conductors within safe limits. These cells are now installed on all railway rotary converters of 1000 K. W. capacity or greater, but do not appear to be necessary on rotaries for lighting service, probably due to the steady load characteristics of this class of service. Another type of trouble has developed on some large modern railway units, which is similar in final results, but possibly originates from different causes. This trouble apparently develops from intense flashing of the d. c. brushes on large capacity units at the time of external short circuits. The arcing from the brushes sometimes spread to the grounded structure of the machine, particularly the armature spider. When the machine structures are actually grounded, these arcs become intensely destructive on account of the large amount of energy available. Considerable trouble has been experienced through the burning out of bearings as a result of arc blisters developing on the shaft within the bearing, due to the flow of these short circuit currents. An apparent remedy has been found in the insulation of the frame work of the machine from ground and the installation of a series relay between the frame and ground which will operate to immediately disconnect the unit from the transmission and distribution systems whenever these commutator arcs develop to the frame work. Since the installation of these relays and the installation of machine frames the severity of flashovers, as this form of trouble is ordinarily known, has been greatly reduced.

The 60 cycle alternating current distribution systems in large communities are entirely different from a direct current system. Energy is distributed throughout the territory by three phase, four wire circuits at potentials approximating 4000 volts. Customers are supplied at low voltages through transformers connected to the 4000 volt circuits. It is ordinarily the practice to connect customer's lighting transformers from one phase to neutral or ground, and power transformers in banks of three across phases with star connected secondaries. Both power and light services may be supplied from a given four wire circuit, but on account of the poor pressure regulation caused by the power load, an effort is made to supply but one class of service from each secondary circuit.

The conversion apparatus in the sub-station may consist of frequency changers, transformers, or a combination of the two, depending upon the availability of 25 and 60 cycle transmission lines supply. The frequency changers consist of three units, a three phase 25 cycle synchronous motor direct connected to a 60 cycle generator. The generator armature is star connected with the neutral point grounded and connected to the neutral wire of the four wire distribution system, and is wound to deliver 4000 volts between phases or 2400 volts between phase and neutral.

The 25 cycle line and bus switch arrangements are similar if not practically identical with those of direct current sub-stations. The frequency changer generator leads connect to 60 cycle buses to which the individual circuits are also connected through oil switches. It is customary on all 60 cycle units and circuits to provide a separate oil switch for each phase.

The frequency changer fields are excited by direct current supplied from 125 volt compound generators either direct connected to the shaft of the unit or driven by separate induction motors supplied from the transmission system. If only one frequency changer was required for each sub-station, an induction motor might be used to drive the 60 cycle generator, but as it is often necessary to operate units in parallel either in the same sub-station or over connecting tie lines, and a variation in relative slip between the motors of the several units would introduce phase differences in the generators, which would in turn seriously interfere with the proper distribution of load between units. It is a well known characteristic of frequency changers that when operating in parrallel, the load division between units is inherently fixed and cannot be changed by the operator. A variation of the generator excitation results merely in the changing of the power factor and causes a circulation of wattless current between units.

The starting and putting into service of frequency changer sets is considerably more complicated than the same operation applied to rotary converters. A considerable number of the units of 1000 K. W. and less capacity are started and accelerated from rest to full speed by connecting them to a three phase auto-transformer, or starting compensator. This starting compensator is wound to receive full line pressure and to deliver a potential to the motor windings varying from 30% to 50% of the line pressure. The motors start in the manner of polyphase induction motors, by reason of special conductors installed on the machine pole phases, acting as a form of induction motor squirrel cage rotary winding. When the frequency changer motor has reached synchronous speed, the fields are excited, and the armature windings disconnected from the auto-transformer and connected directly to the full transmission line potential. In some installations, where the transmission line potential is considerably higher than that for which the motor is designed, transformers are used with special secondary taps for starting purposes, which obviates the necessity of a special starting compensator. After starting the motor of the unit, and before the generator can be connected to the 60 cycle buses, it is necessary to determine the phase relation of the generator to the bus. A 25 cycle to 50 cycle frequency changer may have its motor in phase with the 25 cycle system, i. e., operating at no load, and with the motor and generator field excited, but the generator may be in any one of five different phase positions, with reference to the 60 cycle bus, only one of which is correct, and providing also that the 60 cycle bus is being supplied from a frequency changer connected to the same 25 cycle transmission system as the incoming unit. The proper phase relation is determined by means of a synchronizer and if the relation is not correct the motor which must be opened and closed again after the motor armature has fallen back through 360 electrical degrees, or one pair of poles, as frequently expressed. The latter operation is repeated until the proper phase relation with the 60 cycle bus is obtained. Where exciters are direct connected to the frequency changer shaft, they are sometimes used to start the units, but the synchronizing operations are identical in principle to those previously described.

Where conditions are favorable to the installation of 60 cycle units in the central generating stations, frequency changers in substations may be replaced by transformers, greatly increasing the sub-station conversion efficiency and simplifying operation. These transformers are usually three phase with star connected secondaries and are generally air cooled in the older installations and water and oil cooled in later installations. No sychronizing operations are necessary except as a check to make certain that the transformer about to be put into service is being supplied from the same transmission system as those already in service.

With both frequency changers and transformers in a given sub-station, the frequency changer can frequently be used to good advantage as a synchronous condenser for correcting the power factor of the load on the 60 cycle buses, particularly when a considerable portion of the load consists of induction motors.

All connections to machines, transformers, and buses are made through oil switches, controlled from the switchboard, which contains only meters, oil switch controls and in some instances the excitation system switches and buses.

In the 60 cycle distribution there is no interconnection between circuits after they leave the buses. Each circuit is complete in itself and independent of all others, and should its switch be opened from any cause, becomes entirely dead. On account of the separation of the individual circuits, it is necessary to provide means to control the potential of each circuit independent of the others. This is done by means of single phase induction type regulators connected in each phase of the circuit. These regulators are oil cooled and consist of movable primary and stationary secondary windings, and are somewhat similar to the potential regulators used in connection with rotary converters. The mechanical position of the motor or primary element may be changed through the operation of a small motor controlled from the switchboard, thus varying the potential on the circuit.

In lighting service demands for close pressure regulation are insistent and as hand controlls may be at times somewhat uncertain, automatic voltage control relays are provided for the individual circuits. These consist of delicate solenoid type contact making volt meters installed on the circuit switchboard panels, and control the action of relays which in turn control the circuit regulator motors. The contact-making volt meters are supplied from the potential and current transformers of each circuit. Artificial reactance and resistance corresponding to the circuit characteristics are connected in this volt meter circuit and adjusted so that the volt meter indicates a potential corresponding to the potential at a point out on the service circuit, remote from the sub-station, which is representative of the average potential at the customer's premises.

The 60 cycle switchboard panels contain all the necessary control switches and instruments. Each transformer and frequency changer requires primary and secondary controll switches, indicating wattmeters, and ammeters for each secondary phase, and the relays for the protection of the unit. Each circuit panel contains control switches, ammeters, wattmeters, contact making volt meters, and overload relays for each phase of the circuit. The condition of each oil switch, whether open or closed, is indicated by green or red signal lamps, located on the panel adjacent to the control switch and enables the attendant to quickly determine the conditions in the sub-station in case of trouble. The 60 cycle distributing buses and circuits are all carefully shielded and protected in a manner somewhat similar to the transmission line and buse equipment and are arranged in units, one for each circuit and transformer. Each unit includes a structure containing all oil switch mechanism, current and bus potential transformers, regulator and high tension switch disconnects, necessary to that unit. The individual circuit units also have special knife blade switches to permit of the transferring of circuits, phase, loads, to adjacent units, in event of defective oil switches or regulators. The practice of installing circuit and transformer equipment in units, permits of a ready standardization of construction and facilitates repairs and extensions.

Each circuit phase is protected by an overload relay which opens the circuit switch when short circuit occurs. The transformer has no overload protection but is protected with a form of differential relay which will operate only in case of break down or short circuit in the transformer itself. This is accomplished by connecting current transformers of suitable ratios to the primary and secondary leads of each phase, in opposition through the oil switch tripping relay.

As practically all oil switch controls require direct current for operation, it is important to provide sufficient storage battery capacity to supply the requirements of the sub-station in event of an interruption of the source of transmission supply, as the attendant will be greatly handicapped by the failure of the remote control system. In d. c. sub-stations with system battery connections, a supply is available to cover all ordinary exigencies, but in an a. c. sub-station this reserve is not available, consequently small 125 volt batteries are provided, together with the necessary charging facilities, usually in the form of a mercury arc rectifier.

Sub-station lighting is also of great importance, and emergency lights are generally provided, supplied from system batteries in a case of d. c. sub-stations and from the emergency batteries in a. c. sub-stations.

Reliable sources of power are also necessary for the operation on blowers supplying air blast transformers. This may be accomplished by installing individual motor driven blowers for each air blast unit, with the motor power supplied from the apparatus requiring the air blast. Facilities should be provided however, by installing additional spare blowers or a system of interchangeable air chambers so that an air blast unit will not be put out of service by the failure of a small blower set.

Sub-station equipment is preferably installed in substantial buildings especially designed for the purpose, where ample ventilation is available and where apparatus can be installed with good attention to convenience and safety of operation. No installation can be made entirely safe as against the possibility of breakdown, consequently it is also of great importance that apparatus and equipment be accessible for speedy replacement or repairs. In conjested districts, where space is limited, there is, by necessity, considerable conjection of equipment, but no such condition can be allowed to interfere with ample ventilation for removing the heat developed in the equipment, in order to avoid deterioration of insulation and also to avoid unnecessary discomfort for the attendants. Excessive operating room temperatures and inaccessibility for repairs constitute hazards to the security of the service and cannot be readily justified.

The final consideration in plant design and operation is to obtain reliability of service and consequently the best of equipment and forms of construction to the small detail, must be ambodied in the installation.

THE ARMOUR INSTITUTE OF TECHNOLOGY INTERNAL COMBUSTION ENGINE ENGINEERING LABORATORY.

BY DANIEL ROESCH,

Associate Professor of Gas Engineering, Armour Institute of Technology.

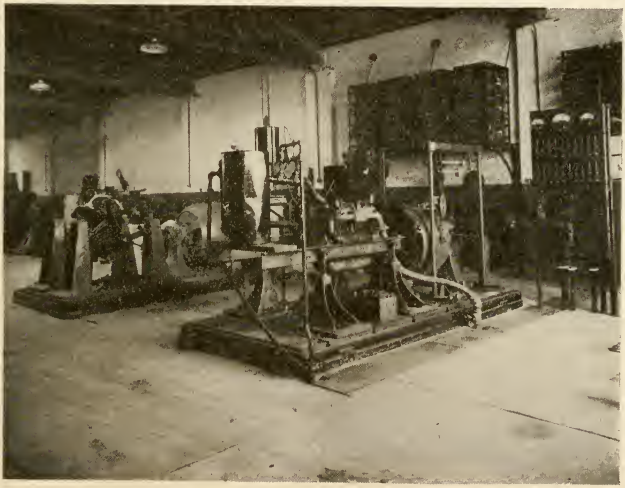
All of the internal combustion engines and accessory apparatus of the Armour Institute of Technology are at present located in a new unit type laboratory located just north of Machinery Hall at 3338 to 3340 Federal Street. The building is of one story brick and terra cotta construction, designed with a monitor ventilating sky light and wall ventilators and occupies a ground area 50x85 feet.

The Engineering Laboratory.

As one enters the main center door from Federal Street, the right side of the building has the following apparatus in the order named:

Four electric dynamometers of 1-20-100 and 300 horsepowers respectively. The first machine was built at the Institute for small power determinations, and measurements as low as one

one-hundreth horsepower are made with accuracy. Investigations and tests for power consumption of automobile fans, magnetos and tire pumps can be made with this machine at speeds up to 3500 R. P. M. The 20 horsepower dynamometer is designed for motorcycle engine tests at speeds up to 5000 R. P. M. The 100 horsepower unit will absorb its rated power at speed from 1200 R. P. M. to 2500 R. P. M. and the 300 H. P. unit will take care of its normal rating at speeds from 1350 to 3500 R. P. M. The latter is of the latest type and especially designed for aeroplane engine work. Its construction embodies the conventional interpole winding and also pole tip windings to insure sparkless commutation for all loads and speeds.



Two Electric Dynometers, showing Chalmers 6-30 engine ready for test of the smaller dynometer.

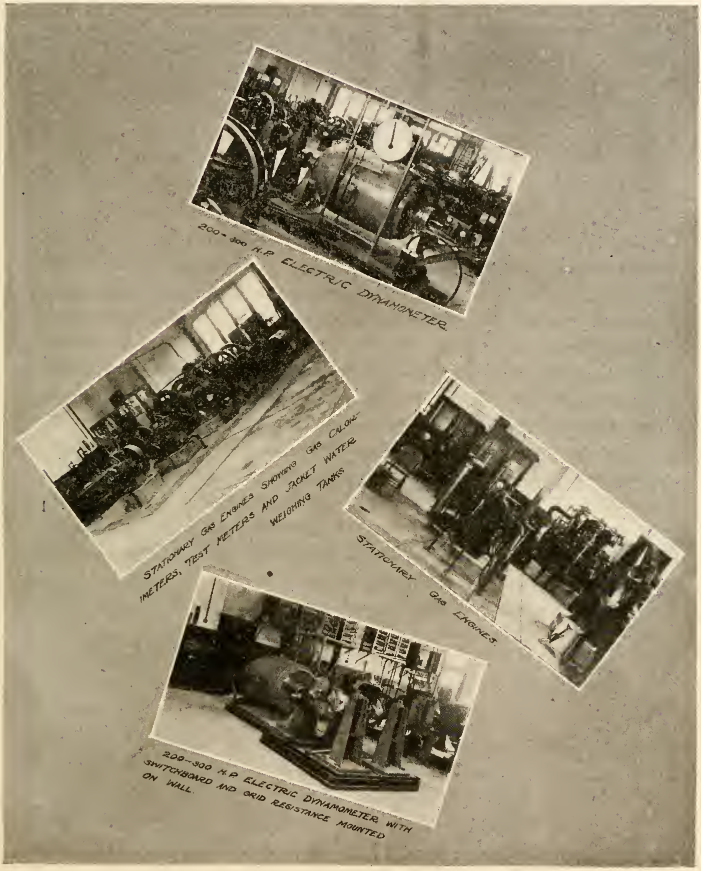
Each of the above units has electric tachometers for instantaneous speed indication and continuous counters electrically operated for test runs. Two electrically operated gasoline weighing devices are available for any of the engines undergoing tests as well as a Holley fuel indicator and other volume measuring devices.

Following the electric dynamometers are four automobile engines fitted with water and fan brakes. The engines include Buda, Rutenber, Ford and Teetor makes and a Standard water brake. Two other water brakes and the fan dynamometer have been designed and built at the Institute. The four outfits are used for carburetor and ignition adjustment and practice as well as for horsepower and fuel economy determinations.

Toward the rear of the building on the right side there are:

1 4-horsepower marine engine, equipped with prong brake.
1 ½-horsepower air cooled engine, belted to a ¾ K. W. Generator.
1 Tire testing machine equipped with a Kenerson transmission dynamometer.
1 Rear wheel testing stand, fitted with a horsepower meter, for automobile chassis tests.
Oil cabinets and gasoline pump with underground storage tank.

As one enters the main center door from Federal Street, the left side of the building has a 14x20 ft. office for instructors' use and for the more sensitive accessory apparatus. Just outside the office are cases for carburetors, ignition devices, log forms, tools, etc. West of these are arranged the stationary engines represented by the following: Rider Hot Air engine; DeLaVergne oil engine; Mietz & Weiss kerosene engine; International Mogul kerosene and distillate tractor type engine; Fairbanks-Morse gas engine; and a Westinghouse 3-cylinder vertical gas engine belted to a 110 or 220 volt double generating set. The latter is arranged through proper switch board connections to supply 110 volt direct current for summer work in charging batteries of the Electrical Department or for emergency service of light or power in any department of the Institute. The unit is available to supply 220 volt current to the electric dynamometers for heavy torque at low speeds when motoring. This unit is also available for overall efficiency tests of a gas engine driven electric generator with water rheostat load. Each of the above stationary engines is equipped with a prong brake indicator, water and fuel



200–300 H.P. ELECTRIC DYNAMOMETER.

STATIONARY GAS ENGINES SHOWING GAS CALORIMETERS, TEST METERS AND JACKET WATER WEIGHING TANKS

STATIONARY GAS ENGINES.

200–300 H.P. ELECTRIC DYNAMOMETER WITH SWITCHBOARD AND GRID RESISTANCE MOUNTED ON WALL.

measuring devices, etc., so that heat balance tests can be conducted.

Underlying the entire laboratory is a system of 6 inch exhaust piping to which all of the engine exhausts are connected. This pipe leads out of the alley side of the building and rises above the roof of the building. It is fitted with a water seal trap which automatically removes all water of condensation or water injected into the exhaust line for cooling purposes.

In addition to the purchased apparatus the equipment includes over ten thousand dollars worth of appliances donated by manufacturers.

A system of floor trenches extends around the inside wall of the building and around the stationary engines and electric dynamometers. This provides space for water and fuel piping and does away with overhead pipe lines. These trenches are covered with checkered cast iron plates cast in the Institute foundry. The building is heated and lighted from the main power plant of the Institute, having direct connections by underground conduits through the alley in the rear to Machinery Hall.

FIRE TESTS OF BUILDING COLUMNS.

BY NORMAN F. KIMBALL,*

Instructor in Fire Protection Engineering, Armour Institute of Technology.

For the purpose of determining the ultimate fire resistance of large building columns and the fire-resistive value of various kinds of column protection, the Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, and the Bureau of Standards of the Department of Commerce are jointly conducting fire tests of building colmuns at Underwriters' Laboratories, in Chicago.

The need for an investigation of this kind has been manifest for many years and, to date, very few tests have been made under conditions approximating those of service. The data gained from actual fire experience has but comparatively little value, inasmuch as many variable and unknown factors are present in every case. The necessity for the investigation is further shown by the fact that the requirements of different companies and governing bodies differ widely in regard to the various materials that are used for the protection of columns.

The investigation is being made with the object of ascertaining (a) the fire-resistance of representative, centrally loaded columns used in building interiors, under conditions approximating those of service; (b) the fire-retardant value of the different kinds of column protection that are at present commonly employed in protecting columns against fire; (c) the effect of applying fire streams to columns while in a highly heated condition; and, (d) for the purpose of obtaining data to serve as a basis of classifying column protection for various classes of buildings, and to also furnish data that will serve as a guide in determining the proper test conditions for further work.

The first column was tested on June 28 and tests are run on the average of two per week; the tests requiring, in all, about twelve months for completion.

The apparatus used in these tests, a general view of which is shown by Fig. 1, was designed especially for the purpose, and consists of a carriage and traveling crane for handling test columns, a furnace in which the columns are subjected to fire, a hydro-pneumatic ram, and the necessary retaining frames for applying the loads to the columns, the apparatus for measuring temperature, the apparatus for measuring the deformation of the test columns, and the apparatus used in the Fire Stream Tests.

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*Class of 1912.

Test Apparatus.

The carriage used for handling the test columns is suspended by means of trolleys from I-beams which are attached to the ceiling. The carriage is provided with lifting screws which are attached to the upper bearing plate of the test columns, so that the column can be lifted and conveyed to a traveling crane and then into the test furnace. The test column is carried from the crane into the test furnace by a truck which is mounted on the carriage.

The test furnace, in which the columns are subjected to fire, is 7 feet square, in horizontal cross section, and has a height of 10 feet, exclusive of two shallow pits at the bottom to receive the falling material and carry off the water during the Fire Stream Tests. The sides of the furnace are formed by stationary brick walls on two of the opposite sides, and two movable brick walls mounted in steel frames provide the other two sides of the enclosure. The movable walls are suspended by trolleys from overhead beams. The top of the furnace is of heavy fire clay blocks supported by a steel frame, and is partly removable to permit the installation of the columns to be tested. The bottom is formed by the fire-proofing on the steel bearing plate and retaining frame of the loading apparatus. The sides of the furnace are provided with observation windows covered with mica and so arranged near the top, middle, and bottom that all parts of the column can be observed during the test.

The furnace is heated by means of four 4-inch burners of special design which extend into the bottom of the combustion chamber at the corners. Gas is supplied to the burners through mixing tubes connected to circulating mains located in a shallow pit under the floor outside of the furnace. Each burner is provided with valves for regulating the air and gas. Secondary air inlets extend through each side of the furnace, to supply the additional air necessary to distribute the flames about the test column and to complete combustion. Each air inlet is provided with a regulating valve. The air is obtained from an electrically-driven blower. Four 13-inch flues extend from the top

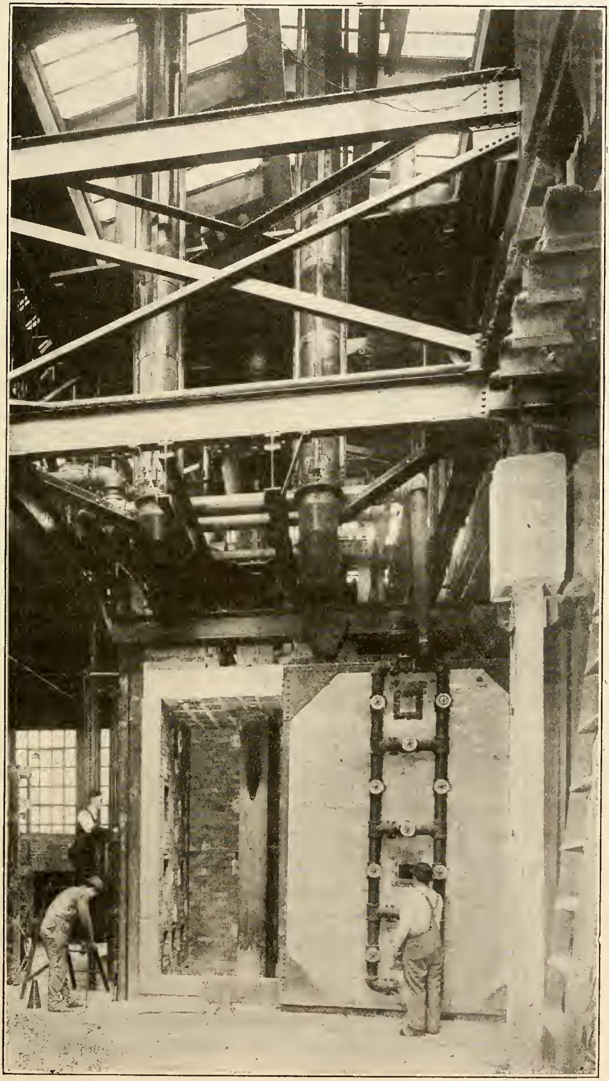


Fig. 1.

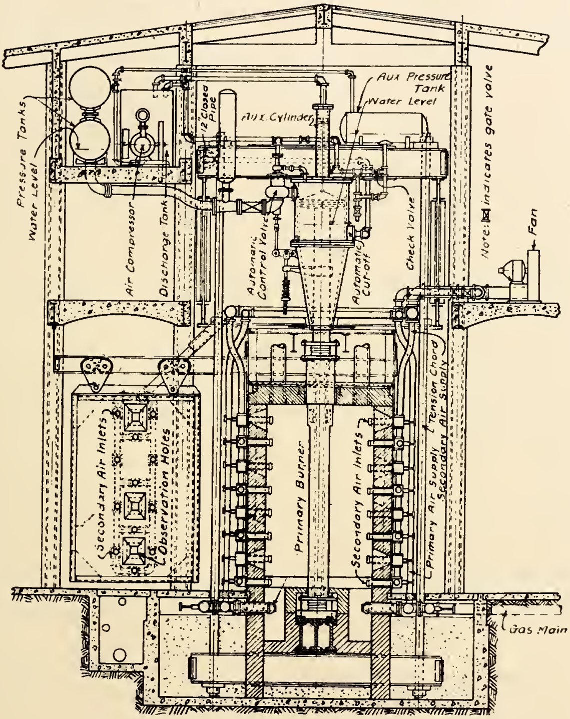
of the furnace through the roof of the building and carry away the products of combustion.

The apparatus employed in applying the loads to the columns under test consists, essentially, of a hydro-pneumatic ram, restraining frames, the pumps and tanks for supporting the pressure, and the accessory pressure-indicating, controlling, and recording apparatus.

The ram has a rated capacity of about 256 tons. It is bolted to heavy steel beams which form the top of the restraining frame in such a manner that it will engage the top plate of the test column when it is in position. The test column transfers the compression to the beams, which constitute the bottom of the frame, and these complete the action of transferring the stresses back to the top through steel tension chords forming the sides of the frame. The framing which supports the restraining frame at the top is also designed to aid in laterally supporting the lower end of the ram and resist any racking which might be set up by eccentricity of the loads when the test columns are deformed in the tests. The ram is designed to maintain the load on the test column and to develop characteristic deformation at the point of failure.

The ram is connected by means of a 6-inch pipe to two steel pressure tanks in which the water and air pressure used to operate the ram are stored. A control valve is provided in the piping which can be set so as to automatically close and shut off the pressure after any predetermined downward movement, less than 24 inches, of the plunger has taken place. In the event that the automatic control valve should fail to operate, the ram is also designed to absorb the impacts and withstand the pressures. In order to independently lower and raise the plunger of the ram, an auxiliary cylinder and pressure tank is attached to the ram at the top. The air and water pressures, as high as 500 pounds per square inch, are supplied by an electrically-driven water pump and air compressor. The necessary connections, valves, and pressure gauges are provided for the manual control of the loading apparatus.

The deformation and deflection of the columns during test are obtained by measuring the movements of protected wires which are attached on each side of the column; one pair of wires being attached 37 inches below the other set. One end of wire



SECTIONAL ELEVATION OF TESTING MACHINE
Scale: 3/16" = 1'-0"

is attached to the column and the other end is weighted and passed over an idler at a point as far distant from the furnace as the room conditions will permit. The movement of these wires is accurately measured at intermediate points on the wires, and from the known ratio of distances the true movements of the column throughout the test at the point of attachment are calculated.

The temperatures within the furnace are indicated by means of thermo-couples inserted through the walls of the furnace. The furnace temperatures are taken by means of platinum and platinum-rhodium and "Hoskins chromel alumel" thermo-couples. Both types of furnace thermo-couples are protected by porcelain tubes and are located at two levels in the furnace, with couples placed in four different positions for each level. The temperatures of the column under test are taken by iron-constantan couples located at four different elevations on the column, with one or two couples at each elevation, attached to the structural portion of the columns and at some elevations an extra couple is inserted in the protective coating. The temperature measurements are made on potentiometer indicators and the connections are so arranged that any couple desired may be put on to a recording potentiometer and a graph of the temperatures can be taken.

For the purpose of subjecting the heated test columns to the action of fire streams, special 4-inch hydrants are employed, a hydrant being located on each of the two sides of the furnace that have movable walls, at respective distances from the middle of the furnace of approximately 26 and 39 feet. A standard playpipe with a 1⅛-inch nozzle and a pressure gauge tapped into its base is used. The hydrants are connected with a 6-inch underground main supplied by a 4,000-gallon pressure tank and an electrically-driven fire pump having a capacity of 500 gallons per minute.

Test Column.

The test columns which are being used in the tests now under way are those designed to carry approximately 50 tons, these columns being tested first with the thought that the data obtained will, in addition to furnishing information relative to lighter column sections, afford data that may serve to simplify the investigations of columns designed for greater loads.

The types of columns being tested include rolled steel sections, built-up steel sections, round cast iron sections, steel pipe filled with concrete, vertically reinforced and hooped concrete columns, and some wooden columns. The built-up steel sections include plate and angle, plate and channel, I-beam and channel, latticed angle, and star-section columns. At least one of each of the sections is to be tested without protection; others are to be partly protected with concrete; and still others will be completely protected with various thicknesses of concrete, clay tile, gypsum blocks, plaster on metal lath, and common brick, in accordance with the methods commonly employed in practice. The columns that are protected by concrete, clay tile or gypmsum block, are tested in the unplastered condition, since in some types of buildings plaster is not applied.

With the exception of two or three, all of the test columns are 15 feet 8 inches long between bearings, with the upper three feet made of extra heavy section, to serve as a medium for the free transmission of the load from the ram through the roof of the furnace to the heated portion of the column. In calculating the safe rated load of the column an effective length of 12 feet 8 inches is taken. The test columns are provided with two brackets near the top to stimulate the details used for beam and girder supports and conditions affecting the application of fireproofing at these points.

The tests on the unprotected columns are made to ascertain the ability with which the columns withstand fire, and to obtain information relative to the influence of the type of column section to be used as a basis for comparing the various methods of column protection.

In some situations in service, space limitations prevent the use of fully protected columns, and for this type columns partially protected by filling the re-entrant portion with concrete are used. In addition to furnishing information relative to this type of protection as compared with unprotected columns, it is also thought that they will give further information on the influence of the type of steel sections on fire resistance.

The tests made on the columns fully protected with concrete furnish data to serve as a basis for comparing the rolled H section and the other sections having the same thickness of covering and made of the same aggregate, and also for comparing the heat insulation and fire resistance values of the various concretes.

The tests on the reinforced concrete columns, of which there are three vertically reinforced square columns, three vertically reinforced round columns, and three spirally hooped and vertically reinforced columns, are made to show the effect of the shape of the column and of the type of reinforcement on fire resistance.

The materials used in the construction of the test columns and protective coatings were obtained from various sources and from various sections of the country, having been selected with the thought in mind of obtaining those representative of their respective classes. The coverings were applied in accordance with plans and specifications drawn to secure average results obtained under ordinary commercial conditions.

The structural steel and cast iron columns are all examined for straightness, eveness of bearing, and soundness of metal and riveting, before being covered or tested. All loose scale is removed and some of the columns are calipered to obtain the true area. To determine the physical characteristics of the metals, auxiliary tension and expansion tests are made on the steel; and transverse, tension, and expansion tests are made on the cast iron. In some cases hardness tests are also made. Chemical analyses are made to check the qualities of the metals.

Four cylinders of concrete are poured from each mix of concrete and comparison tests are made of two after twenty-eight days and of the remaining two on the day the column is tested. Compression, transverse, and absorption tests are made on tile blocks and the temperature of vitrification and fusion is also determined.

After the inserts for the temperature and deformation measurements are placed in position, the protective coating is applied to the column. The coating is placed on the base plate on which the column is tested, and the top plate is also put on in such a manner as to insure an even bearing between the steel section and the coating, thereby making the protection partake of the deformation produced in the column by the load so that both will carry the loads in about the same proportion as would be the case in a building.

The safe rated load on the steel columns is calculated by the following formula:

$$P = A\left(10000 - \frac{70L}{R}\right)$$

and on cast iron columns

$$P = A\left(10000 - \frac{60L}{R}\right)$$

in which

P = safe rated load in pounds
A = area of metal section in square inches
L = effective length of column in inches
R = least radius of gyration in inches

The loads on the reinforced concrete columns are calculated according to the recommendations of the American Joint Committee on Concrete and Reinforced Concrete.

The ends of the test columns are anchored in a manner approximating that obtained in an intermediate story of a properly designed building. The bottom of each test column is anchored to the base plate by four or more ¾-inch bolts, and the top is anchored to the top bearing plate which, in turn, is anchored to the ram. Four of the cast iron columns and two of the steel pipe columns are to be tested with square end bearings and without being anchored either at the base or the ceiling; thus being done to duplicate the standard practice in some parts of the country.

Each column, after having been allowed to season for about fourteen or fifteen months, is placed in the furnace and the top and bottom bearings are adjusted to provide for even distribution of the load. The connections are then made with the temperature and deformation measuring instruments, the furnace closed, and readings taken on all instruments. The safe rated load is then applied and deformation and deflection readings are again taken. The gas is lighted and the gas and air gradually turned on to establish the predetermined temperature rise in the furnace. The temperature rise is uniform for all tests and is such that a temperature of approximately 1550 degrees, Fahrenheit, is attained in 30 minutes; 1700 degrees, Fahrenheit, is attained in one hour; and 2000 degrees, Fahrenheit, in four hours; and beyond this the temperature is slowly increased until a maximum of 2300 degrees, Fahrenheit, is attained in eight hours.

Readings on the gauges indicating the load, on the column and furnace thermo-couples for the temperature, and on the deformation and deflection instruments are taken at frequent intervals up to a point near failure, the load on the column being maintained constant throughout the test. Observations are made of the visible effects of the fire on the column and its protection during the progress of the test.

After failure of the column occurs, the doors of the furnace are opened and the column is allowed to cool. The general condition of the column is noted, the covering removed, and the constituent materials examined for deterioration due to fire.

A DESCRIPTION OF SOME ENGINEERING FEATURES INVOLVED IN THE CONSTRUCTION OF CAMP JACKSON, COLUMBIA, S. C.

BY STANLEY DEAN,*

Associate Professor Hydraulic Engineering Armour Institute of Technology.

General Description.

Camp Jackson is one of sixteen cantonments built during the past summer under the direction of the Quartermaster's Department, to receive the men selected for our National Army from the states of North and South Carolina, and Florida.

The site is six miles from Columbia, S. C., and connected therewith by a spur of the Atlantic Coast Line R. R., a branch of the Columbia City Street Railway, and three highways. It is in a rolling, sand soil country covered with pine growth, so sloping that drainage for all parts of the camp is readily provided.

Preliminary.

After the approval of the site selection by the War Department, in the middle of June, a hasty military topographical survey was made, using sketch boards, compass and distance pacing. This survey was the basis from which a rough map was plotted which served for the first general layout of the camp. Upon this map was shown the location of the various units, roads, sewer, water and railroad lines, which were then tentatively laid down.

The original layout was the standard one issued by Washington, in which provision for 35,000 men was made. In general there were infantry and artillery brigades, engineers train, supply train, sanitary train, telegraph batallion, base hospital, and the various headquarters. To these were later added Remount Station, Ordiance Depot, Incinerator, Garbage Transfer Station, and Six Training Batallions, which it was necessary to fit into the general scheme.

The early receipt of standard building and brigade layout plans from Washington made it possible to begin construction work about June 20th, the engineering forces making more detailed surveys and fitting the layouts to the ground as rapidly as possible, always arranging to so balance their work as to keep well in advance of the forces which the contractor was constantly recruiting and augmenting.

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*Class of 1905.

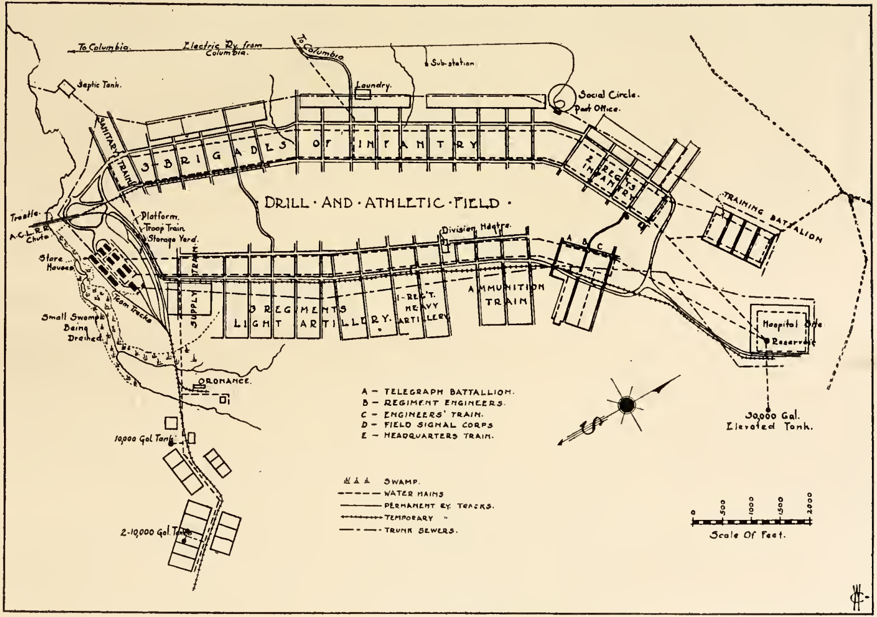
Surveys.

A detailed topographical survey of the entire site was made and mapped to a scale of one inch to two hundred feet, on which contours were plotted to a five foot interval. To do this a gridiron system of transit and level lines five hundred feet apart in each direction were run, and from these as base lines stadia and cross section topography taken to fill in the balance of the area. This survey occupied about three weeks and covered three square miles. Additional lands acquired were surveyed as added.

As the survey progressed final locations of successive brigades, with their road, sewer and water lines, were made on paper as fast as the map was filled in, so that upon completion of the same about the middle of July the positions of all features were determined and from then on only slight changes made as location work in the field carried to greater refinement showed the advisability.

Water Supply.

Water supply for fire and domestic purposes is furnished under contract by the city of Columbia, pumping from their intake and station on the Broad River, from which a sixteen inch cast iron main leads to the camp, a distance of more than six miles. At its entrance into the site, this main divides into two double circuits of ten inch wood stave California redwood pipe which serve the greater part of the buildings, single lines being run to supply the Remount Station, Ordnance Depot and Incinerator Plant. At the Base Hospital, occupying high ground, a circular, reinforced concrete reservoir of 1,250,000 gallons capacity was built, in the form of an inverted frustrum of a cone five feet deep topped by a vertical cylinder six feet more in height. The internal diameter of the cylinder is one hundred fifty feet. The combined inlet and outlet pipe is located in a sump at the center of the sloping floor. A timber roof covering, carried on brick piers, is provided. To furnish greater pressure at the base hospital hydrants, which lie only slightly lower than the reservoir, an eight inch cast iron line was carried to the highest elevation within the camp, half a mile distant, where a



Camp Jackson.

thirty thousand gallon (wood stave) tank was erected on a fifty foot steel tower, assuring pressure for emergencies; there being a difference of elevation of nearly one hundred forty feet between the water surfaces of tank and reservoir. The remainder of the camp lay at such lower elevation with relation to the reservoir that ample pressure was obtained at all times. At the base hospital, and adjacent to the reservoir, a pump house containing three centifugal pumps, motor driven, of 350,750 and 1,000 gallon per minute capacities, for feeding elevated tank and emergency work, was built over the junction Y of the lines coming from opposite sides of the camp, in such a manner as to house in all valves. An altitude valve for pressure regulation guarding the reservoir against overflow was located on the main running through this house. As an additional safeguard an overflow outlet pipe was provided one foot below the top of reservoir wall. Near the end of the single line supplying the Remount Station barracks and corrals three 10,000 gallon capacity wood stave tanks on thirty foot timber towers were provided. Hydrants were located 300 to 500 feet apart wherever the line was adjacent to buildings. Proper provision by means of valves was made to insure delivery of water to any part of the camp in case of failure of any part of the line.

Sewerage and Sewage Disposal.

Sanitary sewers of salt glazed, vitrified tile are provided to connect all kitchens, lavatories, etc., to outlets and trunk lines of same material. Lavatories contain sanitary closets, galvanized iron wash troughs and urinals, shower baths, with galvanized iron water service lines and cast iron soil fittings, the whole housed in frame buildings on concrete floors. Branch lines are in general six inches, draining into eight inch street lines, which in turn discharge into eight, ten, or twelve inch outfall lines depending upon number of connections carried and gradient. Along the East and West sides of the camp intercepting lines, varying in size from eighteen to twenty-four inches receive the sewage from the outfall lines and carry it to a junction near the South East corner of the camp, from where it is led through a short single line twenty-four inches in diameter, to a septic tank, constructed of reinforced concrete, fifty-six by one hundred twelve feet in plan and averaging twelve feet deep. The liquid effluent from this tank discharges over a measuring weir into a dash chamber in which, governed by the head over the weir it is treated with a varying amount of liquid chlorine, after which it is allowed to flow into a nearby creek. Sewage from the barracks and operating rooms at the remount station is received in a concrete sump chamber from which it is lifted by four inch, vertical, centrifugal pumps, motor driven, and pumped into the West branch of the trunk sewer. Small, square, brick manholes were specially designed for changes of alignment and direction in the six inch lines. For all larger lines standard circular manholes, with molded concrete channelways were built. In order to save excavation on the trunk lines it was found advisable in numerous places to use drop manholes. In all, some thirty miles of sewer lines were laid. Caterpillar tread Cucketon trenching machines were used almost entirely for trench excavation.

Roads.

Connecting the camp with Columbia, between which is the principal travel, there are three roads of sand-clay. Within the camp the principal roadway, encircling the infantry and artillery brigades and connecting them with the railroad unloading yard and quartermaster's stores is of bituminous macadam. Other roads about the camp are of sand-clay.

Railroad Facilities.

The Atlantic Coast Line serves the camp, entering with a spur line at the South end of the property. Here a five hundred car freight yard, and platforms for the entraining (and detraining) of men and horses, three house tracks leading to ten quartermaster store buildings, and two team tracks are provided. A permanent, single track line extends along the West side of the artillery brigades to the Base Hospital, and others lead to the Remount Station and Ordnance Depots. During construction temporary lines were hastily thrown down by the contractor to serve each brigade with material and thus reduce to a minimum the length of haul by wagon or motor truck.

Drainage.

Lying to both East and West of the building site there were swamps which called for extensive drainage. This was accomplished by using dynamite to blast out principal channels, and to enlarge or straighten creek channels wherever necessary. The streams into which these swamps drained were straightened, deepened or cleared so as to provide clear channelway.

Fire Protection.

Three fire engine houses located just off the main roads are placed to give minimum average run. A one hundred foot, guyed, timber fire tower is centrally located, from the top of which a lookout is kept night and day. The sentry has telephoned connection with the chief's quarters. Between the various brigades and units fire breaks were left in all cases. Chemical extinguishers and hand reel carts were placed in most of the buildings during construction, during which period an engine borrowed from the Columbia Fire Department was on the ground.

Personnel.

The work was begun and carried through to completion under the direction of the Constructing Quartermaster, Major Wm. Couper, U. S. R., having assigned to him as aids Captain Adj. Crunden and Capt. MacDonald, administrative and fire supervision chiefs respectively. Mr. P. H. Norcross, member A. S. C. E., was Supervising Engineer in charge of water, sewers, highways and drainage. The camp layout was made by Mr. Richard Schermerhorn, Jr., member A. S. C. E., city planner. Mr. J. E. Gibbons, as Field Engineer, was in charge of construction. The U. S. Department of Public Roads assigned Mr. W. L. Spoon, Senior Highway Engineer, to advise in the matter of highway location and construction. Mr. Roscoe L. Smith, of the National Board of Fire Underwriters, acted in similar advisory capacity with respect to water supply and fire prevention. The contractor for all except roadwork was the Hardaway Contracting Co., for whom Mr. H. B. Crawford was General Superintendent. R. M. Hudson Co. constructed all roads. The writer was Chief of Surveys during the first half of the work, and later became Principal Assistant to the Supervising Engineer.

ENTROPY: WHAT IS IT?

BY C. V. KERR.*

Of the various conflicting views taken from many standpoints by different observers of a rather vaguely discerned object, it may be possible to find material with which to construct a clearly defined and useful notion of entropy. It is agreed that entropy remains constant during an adiabatic expansion when heat as such is neither added or abstracted; and that heat added during isothermal expansion causes a change of entropy. But *what* remains constant or changes with a change in the character of the expansion? In seeking an answer to this question and passing from definition to mathematical analysis we may follow the steps taken by an accepted textbook on thermodynamics.

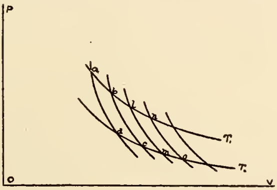


Fig 1

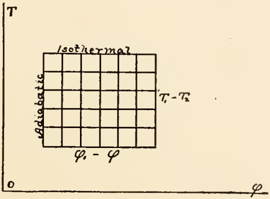


Fig 2.

In the fourth edition of his Thermodynamics, Prof. Peabody says at p. 23, "The name given to this function or property which remains constant during an adiabatic change, is *entropy.*" This is not quoted as a definition—it is merely a view common to all observers. But on p. 34 is found this clear cut statement: "In fig. (1) let the isothermals *ab* and *cd* be extended indefinitely and let a series of adiabatics be drawn cutting off equal areas *abcd, blmc* and *lnom,* etc.; we shall then have a series of intervals of entropy depending upon the foot pound. To make the scale of entropy definite, we will assume that the isothermals *an* and *do* are one degree apart, and that the initial cycle *abcd* is so drawn that it represents the change of one thermal unit into work; for the English system the area *abcd* represents 778 foot pounds." Note that this unit area is a Carnot cycle bounded by isothermals and adiabatics. And again on p. 35 he says: "The area of the strip between the adiabatic *bc* and the isothermals *ba* and *cd* both extended indefinitely towards the left is infinite; consequently there is no absolute zero of entropy and we shall therefore be able to calculate differences of entropy only. The area of the typical cycle chosen for measuring intervals of entropy is large, equal to 778 foot pounds; consequently the numbers expressing changes of entropy will be found to be small."

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*Engineer, American Wall Works.

In brief, if the isothermals are several degrees apart and the adiabatics several unit distances apart the quantity of heat represented by the enclosed area will be

$$Q = (T - T_1)\ (\phi - \phi_1) \dots\dots\dots\dots\dots\dots (1)$$

as shown in fig. (2) which is an elementary entropy-temperature diagram where the ordinates are changes of temperature and the abscissas changes of entropy. Again if the lower temperature is zero and the distance between the adiabatics is very small, this equation becomes

$$dQ = Td\phi, \text{ or } d\phi = \frac{dQ}{T} \dots\dots\dots\dots\dots\dots (2)$$

Integrating between limits,

$$\phi_1 - \phi = \int dQ = C_v \log_e \frac{T_2}{T_1} + (C_p - C_v) \log_e \frac{V_2}{V_1} \dots . (3)$$

in which C_p and C_v are the specific heats for constant pressure and constant volume. This form of equation for change of entropy, with others similar, is given on p. 70 of Peabody's Thermodynamics and is assumed to be true for any reversible process. Consider first an isothermal change.

Then $T_2 = T_1$ and $\log_e \frac{T_2}{T_1} = O$; hence

$$\phi_1 - \phi = (C_p - C_v) \log_e \frac{V_2}{V_1} = A\ R \log_e \frac{V_2}{V_1}, \text{ in B. t. u.} \dots (4)$$

where $A = \frac{1}{778}$ and *R* is a constant peculiar to each gas. The relation between pressure, temperature and volume for a perfect gas is given by the equation,

$$\frac{pv}{T} = \frac{p_1 v_1}{T_1} \text{ from which } p\ v = \frac{p_1 v_1}{T_1} \times T = R\ T$$

in which v_1 is the volume of one pound of the gas at the freezing point T_1 absolute, and atmospheric pressure p_1 per square foot. Thus for air,

$$R = \frac{p_1 v_1}{T_1} = \frac{14.7 \times 144 \times 12.391}{32 + 460.7} = 53.22$$

The increase of entropy for a perfect gas does not, therefore, depend upon pressure or temperature but only upon the ratio of expansion. Even that may be fixed at pleasure. Assume for air that $\frac{V_2}{V_1} = 10$, then,

$$\phi_1 - \phi = A\ R \log_e \frac{V_2}{V_1} = \frac{53.22 \times 2.3026}{778} = 0.158 \text{ B. t. u.}$$

and apparently that value is true throughout the $p\ v$ plane. Or if the entropy is to change by unity, then,

$$\phi_1 - \phi = 1 = A\ R \log_e \frac{V_2}{V_1}, \text{ from which}$$

$$\log V_2 = \frac{1}{AR} + \log_e V_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The expansion thus found will be very small for one foot pound and very large for one thermal unit; but the dimensions of this unit Carnot cycle can be found at any point.

Or, suppose that the expansion is adiabatic. The relation between the temperature and volume is $T_2\ V_2^{K-1} = T_1\ V_1^{K-1}$, in which $k = \frac{C_v}{C_p}$. These conditions change equation (3) to

$$\phi_1 - \phi = C_v \log_e \left(\frac{V_2}{V_1}\right)^{1-K} + (C_p - C_v) \log \frac{V_2}{V_1} \ldots\ldots\ldots\ldots (6)$$

$$= \left(1 - \frac{C_p}{C_v} \right) C_v \log_e \frac{V_2}{V_1} + (C_p - C_v) \log_e \frac{V_2}{V_1}$$

$$= (C_v - C_p) \log_e \frac{V_2}{V_1} + (C_p - C_v) \log_e \frac{V_2}{V_1}$$

Hence, $\phi_1 - \phi = 0$ and there is no change of entropy during adiabatic expansion. The same conclusion is reached by means of the equations for change of entropy expressed in terms of temperature and pressure or of pressure and volume.

It appears, therefore, that there is a change or increase of entropy during isothermal expansion which is constant for a given perfect gas and ratio of volumes; and that there is no change during adiabatic expansion. But the question is not yet answered as to *what* is constant.

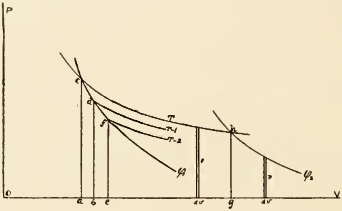

Fig. 3.

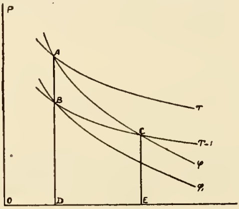

Fig 4

An interesting comparison of results may be found in considering the work done during adiabatic and isothermal expansion. In fig. (3) let dw = pdv be the rate at which work in foot pounds is done during expansion along the adiabatic ϕ_2. Then,

$$W = \int pdv = \frac{p_1 v_1}{K-1} \left(1 - \left(\frac{V_1}{V_2} \right)^{K-1} \right) = \frac{p_1 V_1}{K-1}, \text{ for } V_2 \text{ infinite} \quad (7)$$

At the intersection of an adiabatic with an isothermal $\frac{T_2}{T_1} = \left(\frac{V_1}{V_2} \right)^{K-1}$ and $p_1 v_1 = m R T_1$ in which *m* is the weight in pounds of the gas. One pound is usually considered; but, if other values are allowed, p, v and T may be assumed at random. Under these conditions equation (7) becomes,

$$W = \frac{mRT_1}{K\text{-}1}\left(1 - \frac{T_2}{T_1}\right) =$$

$$\frac{mR\,(T_1 - T_2)}{K\text{-}1} = \frac{mR}{K\text{-}1}; \text{ for } T_1 - T_2 = 1. \quad \ldots\ldots\ldots\ldots\ldots (8)$$

$$= \frac{mRT_1}{K\text{-}1}; \text{ for } T_2 = 0$$

It will be noted that the work done per degree fall in temperature is constant and depends on the value of R for the working gas. And, as no heat is supplied, the work is done at the expense of the available energy of the gas.

Suppose we let ϕ stand for whatever is constant along an adiabatic; and let $Q = \phi\,(T_1 - T_2) = A\,W$ express the equality of heat transformed and work done. Then,

$$\phi = \frac{AW}{T_1 - T_2} = \frac{AW}{T_1}; \text{ for } T_2 = 0$$

$$= AW; \text{ for } T_1 - T_2 = 1$$

Putting in the valve of W from equation (8)

$$\phi = \frac{mAR}{K\text{-}1} = \frac{AR}{K\text{-}1}, \text{ for } m = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

This expresses in heat units the work done per degree fall in temperature which is constant for each gas and better still for all adiabatics. Thus for air,

$$\phi = \frac{53.22}{778\,(1.41 - 1)} = 0.167 \text{ B. T. u.} = 128.8 \text{ ft. lbs.}$$

If the expansion is along the adiabatic ϕ in fig. (3), the areas *abcd* and *bdfe* are equal as each represents the external work done during a fall in temperature of one degree.

Further, since $k = \dfrac{C_p}{C_v}$ and $C_p - C_v = A\,R$, then

$$\phi = \frac{AR}{K - 1} = \frac{C_p - C_v}{\dfrac{C_p}{C_v} - 1} = C_v \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10$$

Referring to fig. (4), the work done during adiabatic expansion from A to C, a fall of one degree, is represented by the area *dace,* which also shows the decrease in intrinsic energy of the gas between A and C. Now, the intrinsic energy at C is equal to that at B on the same isothermal, T — 1; and $\phi AB\phi_1$, represents the decrease in intrinsic energy during a fall in temperature of one degree at constant volume, in other words the specific heat at constant volume, C_v. Hence,

$\phi = A\ W =$ area *dace* $= \phi ab\ \phi_1 = C_v$.............(11)

Now if entropy, a "turning in" or transformation of heat into work and the property of a gas which is constant a adiabatic, is identical with ϕ as used above, then for perfect gases it is the the work measured in heat units or foot pounds done in adiabatic expansion while the temperature falls one degree absolute. It is not only constant along any given adiabatic, but it is the same for all adiabatics. By way of illustration, the entropy of various gases will be as follows:

For Air........ $\phi = C_v \times 778 = 0.16847 \times 778 = 131.1$ ft. lbs.
Oxygen ... “ = “ × “ = 0.1551 × “ = 120.7 “ “
Hydrogen .. “ = “ × “ = 2.4123 × “ = 1876.8 “ “
Nitrogen .. “ = “ × “ = 0.1727 × “ = 134.4 “ “
Sprhtd. St'm “ = “ × “ = 0.346 × “ = 269.2 “ “
Carb'ic Acid “ = “ × “ = 0.1535 × “ = 119.4 “ “
Olefiant Gas “ = “ × “ = 0.173 × “ = 134.6 “ “
C'rb'ic Oxide “ = “ × “ = 0.1758 × “ = 136.8 “ “
Ammonia .. “ = “ × “ = 0.299 × “ = 232.6 “ “
Ethel ...... “ = “ × “ = 0.3411 × “ = 265.4 “ “
Alcohol .... “ = “ × “ = 0.32 × “ = 249.0 “ “

If *ch* in fig. (3) is an isothermal, the rate at which external work will be done by expansion between *c* and *h* will be $dw = pdv$ and,

$$W = \int pdv = p_1 v_1 \log_e \frac{V_2}{V_1} = m R T_1 \log_e \frac{V_2}{V_1} \ \ldots\ldots \quad (12)$$

$$= R T_1 \log_e \frac{V_2}{V_1}, \text{ for } m = 1.$$

For any given gas with constant R and for any ratio of expansion, $\frac{V_2}{V_1} = r$, the work done depends solely on the absolute temperature, T_1. Hence the work done per degree absolute is $W = R \log_e r$, in ft. lbs. or $A W = A R \log_e r$ in thermal units. Comparing this result with equation (4),

$$\phi_1 - \phi = A R \log_e r = A W \quad \dots\dots\dots\dots\dots\dots (13)$$

Hence, when the expansion is isothermal, the change or increase of entropy for a perfect gas becomes the amount of work done per degree absolute during a given ratio of expansion, which may evidently be so chosen that the change of entropy will amount to a foot pound or a thermal unit. Or, since the unit area for isothermal expansion, as *abcd* in fig. (1), is a Carnot cycle while that for adiabatic expansion, as *abcd* in fig. (3), is not, the ratio of expansion may be fixed so that for each gas the unit area is equivalent to the specific heat at constant volume. A Carnot cycle is then the unit area for both and,

$$\phi = C_v = A R \log_e r = \phi_1 - \phi \quad \dots\dots\dots\dots\dots\dots (14)$$

Gathering these facts into a general notion and speaking for perfect gases only, *Entropy may be defined as the rate at which heat is turned into work during expansion; or, conversely, the rate at which work is turned into heat during compression. The ultimate unit in all cases is the foot pound.*

For the sake of simplicity, imperfect gases, vapors and liquids have been excluded from consideration. If a clear view can be gained of the function of Entropy in perfect gases, then a guide is secured through the intricate analysis necessary for vapors. After all the task is that of turning heat into work.

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EDITORIAL.

It is of especial interest to Armour men to know that Dean H. M. Raymond has been appointed Secretary for Technical Schools of the Illinois Section on Industrial Training for the War Emergency, Council of National Defense.

The object of the committee is to utilize for war purposes, the training of men already in the various industries; and to devise means whereby unskilled labor can be made skilled, and skilled labor can be trained to a point of higher efficiency. The committee consists of five educators, five men representing labor and five men representing industries. The practical men are chosen in accordance with their experience and knowledge of industrial affairs, and find it their duty to determine the weak points of existing labor conditions, and submit them to the committee as a whole. The duties of the educators are to formulate plans for the remedy of these conditions, and to bring them into effect. Thus, when the practical men determine what industries carry an over-abundance of men, and which ones lack skilled or expert labor, the educators determine a means for training and fitting the idle men for positions where their services are most required. In many instances, past experience in the various industrial organizations serve to eleminate certain educational measures, and to favor others. Besides placing and training labor, a means is also provided for placing and training technical students. This comes under the supervision of the Secretary of Technical Schools.

It is due primarily to the efforts of these committees that the large industries engaged in government work are beginning to operate more efficiently with reference to the labor problem; and that the demands for skilled and expert labor are being complied with.

Other committees and organizations are providing so far as possible, against the inevitable shortage of engineers and applied scientists, which the war is gradually forcing upon the world.

Although first thought might indicate that all energy should be devoted entirely to the development of a huge war machine, the demand of the future must be complied with wherever possible. This fact was brought strongly before the minds of our leading technical educators and industrial heads within a few weeks after the United States entered the Great War, because enlistments had caused an alarming depletion in the ranks of the colleges of engineering and other applied sciences.

It was pointed out by such men as Mr. J. A. L. Waddel, that because the technical schools of Europe have been practically closed since the beginning of the war, the reconstruction of all of Europe and our own over-taxed transportation systems, will be largely the work of American engineers. It was also pointed out, that if the United States were to meet this demand, some means must be taken, not only to stem the swift decline of the attendance of the engineering schools, but rather to increase it.

Therefore, Emergency Councils, such as the aforementioned, were established throughout the country. They have devised means for the retention of engineering students in the draft age, until the time of their commencement; and through current publications and advertisements, are bringing the engineer and his opportunities before the public with a view toward increasing the student enrollment of engineering schools. That they have been successful is verified by the large Freshman classes enrolled in the technical schools.

The following articles taken from leading technical publications serve to illustrate the type of articles and advertisements that have been spread broadcast throughout the country.

H. W. P.

THE COUNTRY NEEDS ENGINEERS.

The following article by Mr. G. R. Wardlaw, appeared originally in the editorial column of the Electrical Engineer, and was reprinted in the Sibley Journal of Engineering. It emphasizes the need which the future will have for trained men—engineers, and again advices that students of engineering schools should continue their courses to completion if possible.

American youths who are not qualified for military service at this time are urged by our leading engineers and economists to take a course of study in an approved technical school. In doing this they will serve their country and themselves, both now and in the immediate future. Those who are born engineers, those who achieve engineering, and those who have engineering thrust upon them will find no lack of demand for their services. Even now there is an ever increasing demand for engineers, owing to the continuous absorption by all the branches of the service of the product of the technical schools. It is a truism that this is a war of engineers. Even the students have gone out. The technical schools of France and Britain are virtually empty. Due to the ravages of war—the destruction of roadways, canals, railways, bridges, water works, public service plants, not to mention whole towns razed and hundreds of ships sunk—there will be no end of work for the engineer once the war is over. What money there is left after interest charges on the big national debts are paid will go toward rebuilding destroyed towns and public works and worn out transportation systems. The debts to be paid are so huge that money will be scarce. This will give the engineer a chance to live up to his reputation as a man who can do for one dollar what any fool can do for two. For a time, probably for a long time, the whole world will have to work hard and save hard to make up for the wanton waste caused by this frightfully expensive conflict. The bread and butter arts will prevail as they haven't prevailed for years, our recent complex modern systems giving way, under stress of economic necessity, to more simple and primitive ways. The cultural studies—the classics and humanities—will, from force of circumstances, make room for the studies that promise maximum output at minimum expense. The scientific method will prevail until the world finds the time and the leisure to cultivate again the amenities of life. Applied science and engineering are synonymous. To conduct the war, then, so that victory will rest with our allies, and to rehabilitate war's ravages once the nations are at peace, means work for as many engineers as our technical schools can turn out. Here indeed is an alluring prospect. All the youth of the land with an aptitude for engineering should lose no time in getting enrolled in some accredited technical school, for what America and her allies have urgent need of now is not idealists and pacifists but hard-headed practical men with a first class technical training. An earnest student in a technical school at this juncture is just as useful to his country as a soldier in the trenches or a sailor on a ship of war.

RELP RE-MAKE THE WORLD.*

"The call of the time is for the engineer or applied scientists, including the physicians and sanatarians. Young men who are ineligible for military service for one reason or another, or can render better service by completing their technical courses, should train themselves to become builders of the future.

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*From Technical Review.

"Vast parts of Europe are in ruins. Our own railroads and industrial equipments will need rebuilding after the terrible strain of wartime. Yet the supply of technically trained men does not meet the demand NOW. When the war is over the demand will be still greater.

"America must take a leading part in the reconstruction of the world. Products of our factories, farms and mines, raw materials and finished products will be needed in enoromus quantities. Physicians and sanatarians must be supplied to aid the wounded and to restore sanatation.

"War is not only fought at the front. And if you cannot serve there you should train yourself technically to direct production of clothing, chemicals, food, munitions and machinery of war. And then in the days of reconstruction to come you can help to repair the ravages of war.

"Men who hold the helm of the Ship of State voice this appeal. Let them convince you that if adapted for applied science you are urgently needed in this field. Read and heed their words. Do not allow the supply of trained engineers, chemists, biologists, agriculturists and physicians to be depleted. You will thereby be performing a patriotic duty and will help the industrial progress of America and the world."

NOTICE TO STUDENTS SUBJECT TO DRAFT.

The following is a partial reprint of the Regulations Governing Enlistment by Engineering Students in the Engineering Branch of the Enlisted Reserve Corps.

Under such regulations as the Chief of Engineers may prescribe, a proportion of the students, as named by the faculty, pursuing an engineering course in one of the approved technical schools listed in the war department may enlist in the Enlisted Reserve Corps of the Engineer Department and thereafter, upon presentation by the registrant to his local Board of a certificate of enlistment, such certificate shall be filed with the Questionnaire and the registrant shall be placed in Class V on the ground that he is in the military service of the United States.

The regulations prescribe that a candidate for enlistment in this branch of the service be, a citizen of the United States, a student of an approved technical school; he must be enrolled and must be pursuing a course required for the degree of Chemical Engineer, Civil Engineer, Electrical Engineer, Mechanical Engineer, Mining Engineer, or some other equivalent Engineering or technical degree. Also he must have made since his entry upon this course at the school, a record of standing which will indicate that he may be regarded fairly as deserving a place among the first third, based primarily on the scholastic records, of the young men who graduated from that institution during the past ten years.

Immediately upon the completion of this course, or upon the discontinuance of the course for other reasons, the student will be given the option of being called into service under his enlistment and being assigned to some one of the Engineering branches of the Army, or of being immediately discharged and taking his place again among those subject to service under the the draft.

President Wilson and Secretary Baker have urged that it is the patriotic duty of all the students in engineering colleges to stay in school if possible until actually called to the colors. The War Department recognizes that technically trained men are essential to all army operations and intends to detail drafted men who have taken engineering courses to the type of service for which their training best fits them. To this end students who may not be recommended for enlistment in the enlisted reserve corps but who remain in school until called to camp are authorized to file with their occupational census questionnaire at camp, a letter from the president of their school stating their special qualifications. The Secretary of War has assured the colleges that every effort will be made to use each student's special training in the specialized occupations of the army.

RECONSTRUCTION DURING AND AFTER THE WAR.

BY DR. G. L. SCHERGER.

Professor of History and Science, Armour Institute of Technology.

"War is the father of all things," wrote old Heraclitus over two thousand years ago. It is becoming more and more evident to us each day that the present world conflict with its colossal destructiveness of life and materials must not be viewed only from the negative standpoint but that the losses will be more than outweighed by the gains. Good often comes out of what seems to be an unmitigated evil. The war will prove a purifying fire. Out of the ashes of the old institutions, phoenix-like, a new order of things will arise.

Never before has there been such a testing of institutions, nations, and civilizations. Never has the truth of the Darwinian theory in the development of history been demonstrated as it is now being demonstrated. The expressions "Struggle for existence" and "survival of the fittest" have become far more real to us than they were before. Weak things are perishing. Only what is really strong and efficient is enduring the test. This does not mean the triumph of brute Force or that right is always on the side of the heaviest artillery, as Napoleon said. It does not mean that Might makes Right but rather that Right makes Might. Truth must win over Error. Ideas must triumph over mere words and party shibboleths. There is an inherent strength in the truth. For this reason the poet is right when he says, "Truth crushed to earth will rise again. The eternal years of God are hers." In the same sense Schiller pronounces the history of the world to be a record of the judgment upon the world.

It would be a rash and perhaps a futile undertaking to find a formula for a war that has assumed such stupendous proportions as the present conflict. The careful historian hesitates to turn prophet. The greatest statesman can take only a step at a time without knowing what the consequences of this step may be. He may unchain forces which he is unable to master. Events generally refuse to shape themselves according to our preconceived notions.

Notwithstanding I hazard the opinion that the war is primarily a contest between two forms of civilizations, the Anglo-Saxon and the German, and that the difference between these two forms of civilization is fundamentally as regards the relation of the individual to the State. The Anglo-Saxon ideal of government is individualistic, the German collectivistic or socialistic. The relation of the individual to the state in the former system is loose, in the latter, close. Extreme individualism reduces governmental control to a minimum, considering that government best which governs least. It emphasizes liberty, which carried to extreme would mean the right of each to do as he pleases. The German system places the State above the individual. It emphasizes the fact that the State is an organism rather than an aggregation of atoms.

No one could possibly be a more ardent individualist than I am, yet I fear that much of our former individualism has already been lost and that much more will go. The truth is that individualism is weak in time of a crisis such as this, which demands the concentration of all energy upon the attainment of our aim.

Extreme individualism has been weighed in the balance and found wanting. The experience of England when she entered a war has been a lesson to the United States. The policy of trying to muddle through in some fashion has shown itself to be expensive and disastrous. America made up her mind that she would profit from England's example and with a speed that has amazed the world addressed herself to the task of mobilizing all the resources of the nation. Miracles have been accomplished. As soon as it became evident that the old volunteer system of raising troops was inadequate conscription was introduced. What Canada and Australia hesitated to do after being in the war for four years, we did almost at the beginning. With incredible rapidity military camps were established in various parts of the country; officers were trained, troops drilled, armies equipped and transported and the innumerable details incident to the adoption of a new military system worked out. With equal celerity and efficiency steps were taken to conserve the food supply of the nation, to eliminate waste, to float the Liberty loans and to register the man and woman power of the country. The latest and most stupendous of these undertakings is government operation of the railroads. The next step will probably be that the government takes over the mines. Conscription of labor may also soon follow. We are thus in the midst of a most remarkable reconstruction. Unmistakably the tendency is away from the old individualistic ideals of government, toward greater concentration and socialisation. Where this development will stop no one can tell. It will probably continue after the war is over, for the new problems which peace will bring, will necessitate a rejustment on even a vaster scale than that which the war brought on.

As government ownership and management replaces private ownership, the tendency toward the democratization of institutions will become more and more pronounced. Political democracy having long since been attained, the next step will be the realization of economic democracy. The old system of exploitation will disappear. Social justice must become a fact. Government must be not only *by* the people, but also *for* the people. It is interesting to observe how the war is hastening its process. In England the large estates, formerly used as hunting preserves and parks to minister to the pleasures of the aristocracy, are now being broken up into small farms, to minister to the needs of the poor. The privileges of the aristocracy are giving away to the necessities of the poor. As the poor man's son serves in the trenches beside the rich man's son, a feeling of brotherhood is being engendered. Great estates and fortunes are being broken up, owing to the enormous taxation and the conscription of wealth. In the old world as in the new, the limitation of profits and the regulation of prices is putting an end to the policy of exploitation. The victory of democracy not only in political affairs, but also in social and economic affairs, seems assured. Even after the war things will not become what they were before, but life will be made more worth living for the average man. True democracy demands this. The movement is world-wide. A new era has come. Its demand is not so much a demand for religious or political reforms as it is for social and economic justice and equality.

THE RESOURCEFULNESS OF THE ENGINEER.

BY E. H. FREEMAN.

Professor of Electrical Engineering, Armour Institute of Technology.

A recent account from the war front in France about a body of American engineers, laying down their shovels and making use of more immediately effective weapons, suggests again the value of resourcefulness to the engineer. This action, performed under the stress of great danger, is typical of what is expected of the engineer in similar, but less pressing circumstances of peaceful rivalry.

One of the engineer's principal functions is to adapt means to the accomplishing of certain ends. In the present war, these means are largely physical in character. They deal with matter and energy, each in its various forms, things with which the engineer is familiar and which his ability enables him to use in the effort to defeat the enemy. Almost every science has contributed some useful information; and history shows that all sorts of devices from the most ancient to the most modern are being employed. It is, therefore, evident that the engineer, with science and history as a part of his fund of knowledge has an almost unlimited field in which to exercise his ingenuity in adapting old or new means in an improved way to secure old or new ends.

This knowledge of things material and the ability to apply it, this resourcefulness of the engineer has given him an opportunity to extend his usefulness to society beyond the strictly engineering field. For example, the position of city manager, which some of our cities have created, is open to engineers. It is true that many city problems involve few things outside of engineering, but there are also other problems which have legal, social and political aspects that may call for greater consideration than the purely material features. It is evident to those familiar with the engineer's training that he can add social and political knowledge to his resources easier than a man trained in other lines can acquire the technical knowledge which the engineer possesses. The engineer is thus in an advantageous position from which to extend his activities and enlarge his sphere of influence.

In a recent discussion by a few alumni of a certain college whose president had resigned, it was suggested by an alumnus, who is not an engineer, that an engineer would make a good successor, provided one could be found who had outgrown his early training and had become sufficiently broad to meet the requirements of such a position. College presidencies are not usually considered within the field of the engineer's opportunities, mainly for the reason that he can secure greater returns for his efforts in other lines; but it is interesting to note that an engineer who has extended his intellectual resources and his ability to use them efficiently—his resourcefulness—may include such positions as a part of his opportunities.

The positions to which an engineer may aspire are, to a very great extent, limited by his resourcefulness. An excellent moral character, is, without question, a prime requisite for any position. The next considerations are the breadth and depth of knowledge and the ability to use it—resourcefulness. Character is largely fixed rather early in life, but resourcefulness may be continually increased to the end of one's days.

MISUSE OF THE WORD ENGINEER.

BY CAPT. N. M. STINEMAN,

Engineer Officers' Corps.

It is indeed unfortunate that in America most people associate the word "engineer" with a man in greasy overalls who runs an engine or a boiler. The man who operates the boilers of an apartment building is called an engineer, although, as we shall see in a moment, the name is entirely a misnomer when applied to him. He may be a good mechanic, but he is not an engineer. The gray-haired man who drives the locomotive of a transcontinental limited, and who holds the lives of hundreds of human beings in his care, belongs to the very highest type of mechanic; but he is not an engineer—except in the United States and Canada.

Much has been said and written on the importance of educating the public to the true meaning of the word "engineer." In this case, as in many others, it is of far greater importance that engineers themselves be educated to the true meaning. So long as engineers use the word improperly, how can they expect to educate the public to the true usage? So long as engineering magazines and textbooks use the word improperly, how can we expect engineers to become entirely clear in its use? It seems obvious that the place to begin is not with the public, but with engineering literature—at the other end of the line.

Now let us investigate the words commonly used in other countries and other languages to designate the man who runs an engine and the man who is a civil engineer (using the latter in the broad sense). To begin with, other languages do not contain a word directly equivalent to the English word "engine." The word commonly used is analogous to the English word "machine" and the different types of engines are designated by proper modifiers. Thus, in French and German, respectively, a steam-engine is a "machine a vapeur" and a "dampf-maschine." In consequence, the man who runs a stationary engine is designated by a word analogous to the English word "mechanic" or "mechanician." Other languages contain a word similar to the word "locomotive" to designate that particular type of engine. The word used to designate the man who runs a locomotive might, in most cases, be translated into English as "locomotive conductor."

The following table shows, in columns 2, 3 and 4, the words commonly used in various languages to designate the men who in this country are known as civil engineers, locomotive engineers and stationary engineers, respectively:

	Civil Engineer.	Locomotive Engineer	Stationary Engineer
French	Ingenieur	Conducteur de machine	Mecanicien
Spanish	Ingeniero	Conductor de locomotora	Maquinista
Italian	Ingegnere	Conduttore di locomotiva	Macchinista
German	Ingenieur	Lokomotiv-fuhrer	Maschinist
Swedish	Ingenior	Lokomotiv-forare	Maskinist
Danish	Ingenior	Lokomotiv-forare	Maskinist
English (England)	Engineer	Engine driver	Engineman
English (U. S. & Canada)	Engineer	Engineer	Engineer

From this table it is evident that in countries other than the United States and Canada there can be no misunderstanding as to the meaning of the word "engineer." Only in the English-speaking portion of North America is its use in a state of confusion. We have succeeded partially, though not entirely, in acquiring the habit of using the correct words in connection with the driving and care of automobiles. Why not correct ourselves in other respects? Nothing could be more logical than the forms used in England, where the civil engineer is known by his true name, the man who runs a locomotive is known as an "engine driver" and the man who runs or takes care of a stationary engine is known as an "engineman."

—*Reprinted from* Monad.

A paper by Professors Doubt and Freud, on "The Determination of Organic Compounds by an Optical Method," was read at the ninety-first regular meeting of the American Physical Society in the Ryerson Laboratory of the University of Chicago on Dec. 1, 1917.

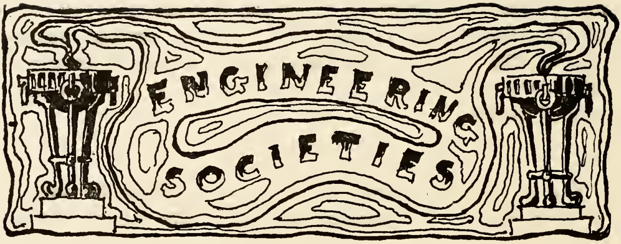
The paper presented the preliminary work as applied to estimations of benzol-toluol mixtures. The work is being extended. The following is the paper as it was presented to the society:

THE DETERMINATION OF ORGANIC COMPOUNDS BY AN OPTICAL METHOD.

THOS. E. DOUBT AND B. B. FREUD.

The index of refraction has long been recognized as one of the characteristics of a body. The index of refraction for a number of wave lengths may be determined by a single photograph of Talbot's bands for a known thickness of a body. Gibbs has proved that for a number of substances his interferential constant which is obtained by dividing the number of Talbot's bands between two spectrum lines by the density of the substance is independent of the temperature. He suggested that this new constant be used in determining the composition of mixtures. We have found no further application of this suggestion. A comparison of this constant with the other so-called constants; namely, Newton's, Gladstone and Dale, and Lorentz and Lorenz, is made in the paper. The values of these constants for Benzol and Toluol are given in the tables and it is seen that the values of the interferential constant differ by the greatest amount. Between the two given lines for a layer of liquid one centimeter thick there are 110 bands more in the case of Toluol than in the case of Benzol.

The U. S. Government has purchased a thousand copies of the fifth edition of Professor Gebhardt's book entitled, "Power Plants." They are to be used as text books in the various Engineering Corps.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President	K. A. Taylor
Vice-President	J. A. Keith
Secretary	V. A. Kerr
Treasurer	H. Anderson

The second meeting of the year was held October 30th in the Engineering Rooms in Chapin Hall. A very interesting talk was given by H. Anderson on the specifications for the McKinly Power Plant. Mr. Clausen discussed the design, construction and operation of Desiel oil engines and answered many questions in the discussion that followed. Mr. Keith talked on the lubrication of motor cars, explaining the different systems of oiling in the various types of cars.

At the next meeting, November 27th, Mr. Taylor spoke on the assembling and testing of oil and kerosene engines, giving some practical details of construction. An interesting discussion followed. Mr. Rehfelt sketched and explained the construction and operation of a modern dispensing machine of the type used in the new Automat lunch-rooms. It certainly is something new., Mr. Wertheimer gave the society the results of his experience as designer of the gas engine valves made by the American Car & Foundry Co. He described the routing of the material through the shop and various other very interesting features.

V. A. Kerr.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Chairman	R. A. Newlander
Treasurer	H. H. Shotwell
Secretary	A. A. Hofgren

The third meeting of the year 1917-18 was held Wednesday, November 7, 1917, in the Electrical Lecture Room. Professor Freeman gave a preliminary talk to the three upper classes of Electricals on types, uses, and advantages of relays.

Mr. D. W. Roper, Chairman of the "Protective Devices Committee" of the A. I. E. E., gave an illustrated lecture on "Relays in Transmission Lines."

The fourth meeting was held Thursday, December 22, 1917. Professor Peebles gave an illustrated talk on the "Electrical Measurement of Thermal Conductivity." The method described is in commercial use in the Mechanical Laboratory of A. I. T., under the supervision of Prof. Peebles.

The fifth meeting was held on Wednesday, December 5, 1917. Mr. V. A. Hain, Specialist for the General Electric Co., gave an illustrated talk on "Industrial Electric Heating." In his talk, Mr. Hain told of the origin, development, present applications, and future possibilities in the field of "Electric Heating," and gave those present a very interesting and instructive meeting.

A. A. Hofgren, Secretary.

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	J. Nitka
Vice-President	H. A. Peterson
Recording Secretary	L. Weiss
Corresponding Secretary	B. B. Cramer
Treasurer	V. M. Crown

The third meeting of the Armour Civil Engineering Society was held December 4 in the Engineering Rooms of Chapin Hall.

Professor Dean gave a very interesting and instructive talk on "The Construction of the Sixth National Army Cantonment at Camp Jackson, South Carolina."

The last meeting of the year 1917 was held December 18, in the Armour Mission.

Mr. Blackwood, of the Barber Paving Co., gave an instructive talk on "The Mining, Refining and Application of Trinidad Lake Asphalt." This talk was accompanied by six reels of fine pictures.

This meeting of the Society was well attended and it is hoped that equal interest will be shown in future meetings.

B. B. Cramer.

THE CHEMICAL ENGINEERING SOCIETY ARMOUR INSTITUTE OF TECHNOLOGY

President	F. R. Johnson
Vice-President	C. W. Muehlberger
Secretary	W. W. Koehler
Treasurer	A. Pearson

A meeting of the A. I. T. Chemical Society was called to order on Monday, November 12, and Prof. H. McCormack gave a talk on the "Features of the Chemical Exposition of New York, September, 1917."

On the third of December Prof. M. B. Freud addressed the society. His subject was the "Development of the Modern Valence Ideas."

The Chemical Banquet, which was held on the 20th of December, at the Auditorium Hotel, was quite successful; several of the Alumni members gave very interesting speeches.

W. W. K.

ADDRESS BY PROF. McCORMACK TO THE A. I. T. CHEMICAL SOCIETY ON OCT. 29, 1917

The Third Chemical Exposition Held in New York on Week of Sept. 24, 1917

Two points were noted in the improvement of this exposition over that of the previous exhibits, and were:

1. Greater variety of products which were also better in quality.

2. Great improvement in the equipment for use in the chemical industries.

The case of filtering machines serves as a typical example. Previously the plate and frame types were shown almost exclusively. Now, however, practically all exhibitors showed continuous types.

Another branch of the industry which is being highly developed is the manufacture of acid resistent materials which are used for pans, cooler coils, valves and are made of silica. These products are found to be indespensible in many commercial processes which require the use of mixed acids for many of the nitration reactions. The residual acid which is left in the above processes has been considerably weakened and in order to be further used it is necessary to denitrate, and concentrate the remaining sulphuric acid. The equipment for accomplishing these last results require the use of the above mentioned acid resistent materials.

The most common chemical operation may be said to be the following:

(a) sulphonation, (b) nitration, (c) chlorination, (d) acteylation, (e) hydrolysis.

The size of the units in which these operations are carried out has considerably increased in the past few years. Three years ago nitrators would probably hold a charge of 3,000 lbs. of mixed acid, whereas now they would contain perhaps 15,000 lbs. of this acid. Most nitrators must be operated at a predetermined temperature which if exceeded would result in the formation of higher nitro bodies. Hence the use of satisfactory cooling means is imperative. Satisfactory nitrators with means for cooling, and made of the acid resisting materials are now being manufactured. For operations in which there is a deposit of a solid material nitrators are being made which are provided with scrapers. Several years ago the average capacity of a nitrator was about 3,000 lbs. which required about 15 hours for completion, whereas, now, units are being made which have three times that capacity and require but 6 hours for completing a run. Formerly earthenware was used almost exclusively in the construction of these units. Specially made acid-proof materials are now employed for this purpose.

There has been a considerable development in the manufacture of silica chemical-ware. The great difficulty in making large sized objects with this material lies in the fact that the fusion point of silica lies but 100 to 150° C. above the point at which it becomes too viscous to mold. In spite of this difficulty, however, silica stills are made of capacity of 75 liters, and tubes of 6″ dia., and 7′ length.

Another interesting feature of the exposition was the exhibit presented by several southern railroads, showing various raw materials obtainable in their localities which may be utilized in certain chemical industries. Several cities also had exhibits to demonstrate the desirability of locating chemical plants in their vicinities.

A particular development was noticed in the production of American dyes. But a few years ago there were only three or four exhibits of dyestuffs, and this year the number was increased to about thirty, most of which presented satisfactory products.

In the line of pharmaceudical chemicals there has been remarkable development. Whereas there was but one firm which exhibited phenolphthalein (which was considerably discolored) in the previous exposition, there were this time five companies with this product which in most cases was free from discoloration. Such chemicals as methyline blue were shown for the first time at this exhibit. Several firms were exhibiting toluene, and napthalene dyes, but as yet the fastest dyes which are made from derivatives of anthracene are not being manufactured on a commercial scale.

It is interesting to note how the developing industry with its competition has reduced the market prices of certain chemicals formerly made only abroad. This condition is particularly noted in the case of benzoic acid which is used largely for food preservatives. At one time not long since, it sold for as much as $12 a pound. At present it's quoted price ranges from $1.00 to $2.00 a pound.

One firm exhibited HNO_3 produced synthetically by the ammonia process. Improvements in the methods for recovering intermediates such as benzol and toluol were noted, as were also refining processes. An automatic operating benzol and toluol still is being manufactured at present. A most noteworthy fact as seen at the exposition was the tendency toward specialization in the manufacturing of chemical equipment. One firm would specialize in stills, another in exaporators, etc. A great diversification within the firms would undoubtedly be desired to permit the complete equipment of newly constructed plants by a single company thus permiting a harmonizing or coordination of all the parts of such a plant.

An educational feature of this exposition was the series of talks occuring two hours in the mornings, and two in the evenings during the course of the week. These lectures were in many cases illustrated by motion pictures. This year the various companies recognized the advantage of having the best technical men in charge of their exhibits. For this reason many recognized authorities were present to offer their advice and counsel.

The first chemical exposition ever shown in Chicago will probably make its appearance in this city next spring.

D. E. Cable, Secretary pro tem.

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	T. Trask
Vice-President	L. Kuttnauer
Secretary	R. Mann
Treasurer	C. Mintz

No important meetings have been held since the last issue of the Armour Engineer; however, a series of very interesting lectures are planned for the immediate future. The dates of these lectures will be announced a few days previous to evenings on which they will be given.

R. N. M.

ARMOUR ARCHITECTURAL SOCIETY.

President	Everett F. Quinn
Treasurer	William C. Wright
Secretary	Armand R. Monaco
Purchasing Agent	Stennet C. Hulburt

One of the first duties of the Society at its next meeting will be the election of a new president. This is made necessary by the enlistment of Quinn into the Ordinance Department of the Army.

The sophomore drawings have been judged, and were declared very good. This is proven by the fact that they drew three first mentions and seven mentions.

The society is planning a number of inspection trips which are to be considered as soon as the weather permits.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

J. J. Schommer Grover Keeth E. G. Hindert

Communications should be addressed to J. J. Schommer,
33rd and Federal Streets, Chicago, Ill.

OFFICERS OF THE ARMOUR ALUMNI ASSOCIATION FOR 1917-18.

Grover Keeth, '06	President
E. C. White, '99	Vice-President
J. J. Schommer	Recording Secretary
J. J. Schommer	Corresponding Secretary
H. L. Nachman, '02	Treasurer
M. L. Flinn, '04	Master of Ceremonies

BOARD OF MANAGERS.

Retiring 1918.	Retiring 1919.	Retiring 1920
E. G. Hindert, '98	T. A. Banning, '07	R. C. Henderson, '02
F. G. Heuchling, '07	H. E. Berkman, '09	B. S. Carr, '15
L. J. Byrne, '04	J. B. Johnson, '12	W. J. Baer, '10

ARMOUR ALUMNI MINUTES.

THE MIDYEAR.

Alumni gathering was held Wednesday evening, 8 P. M., December 12th, in Science Hall at The Armour Institute of Technology.

The meeting differed this year from the former affairs, in that it was a smoker with all food banished.

Fifty-eight were present, smoked their pipes, and listened to a very instructive talk by Dr. F. W. Gunsaulus. He told us of his impressions gained abroad on technical education, its application in the industries and wherein it failed with special application to pottery. This interesting archaeological study was then gone into by the aid of lantern slides and an entertaining lecture by Dr. Gunsaulus.

Lieut. Hamilton, of the Canadian Black Watch, followed the Doctor. The Lieutenant told of many experiences and described many of the death dealing contrivances in use "over there."

His talk was also immensely enjoyed and many side lights of the frightful war were learned.

A short business meeting was held after the entertainers or rather instructors. President Keeth was in the chair.

Byanskas' resignation as recording secretary was accepted and John J. Schommer was elected to fill the vacancy.

The suggestion that regular periodic meetings be held throughout the year for similar talks on various instructive subjects was discussed. It was decided that the idea was splendid but couldn't be, due to the expense involved.

The meeting was then adjourned.

Norman J. Goorsky died Aug. 5, 1917, at Washington, D. C., aged 21 years. He was a member of the class of 1917 and of Tau Beta Pi. He was buried from his home at 2123 N. Tripp Ave., Chicago, Ill.

The following is reprinted in part from the Chicago Examiner of Nov. 19, 1917:

Camp Logan, Houston, Tex., Nov. 19.—Eighty men of the One Hundred and Eighth Engineers were graduated from the demolition school today by Lieutenant William M. Bready because they have successfully learned more than a dozen ways of blowing up Germans in large numbers by the use of land mines.

Lieutenant Bready tomorrow will start a school for officers in making and using explosives. He will teach them to make hand grenades.

At the time of this announcement, Bready had received a commission as 2nd lieutenant of the One Hundred and Eighth Engineers. Since then he has been made 1st lieutenant.

William Bready is a graduate of the class of 1916, Armour Institute of Technology.

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CHICAGO, ILLINOIS

VOLUME X NUMBER 3
MARCH, 1918

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Herbert W. Puschel

The Armour Engineer

VOLUME X MARCH, 1918 NUMBER 3

THE MANUFACTURE OF MANGANESE STEEL CASTINGS

BY BRADLEY SAYRE CARR*

Sales and Mechanical Engineer, American Manganese Steel Company, Chicago

In the field of engineering, manganese steel has for a number of years been a familiar term. Yet, it is doubtful whether full consideration has been given to the development of this metal and the ever increasing number of applications that are being made to machinery and equipment for a variety of industries.

The growth of the manganese steel foundry industry has led to specialization, and at present there are several large steel foundaries in the United States and abroad that concentrate their efforts on the production of high manganese steel castings. The plants in the United States now have a combined capacity of approximately 70,000 tons per year.

Manganese steel was developed originally in England, largely through the efforts of Sir Robert Hadfield. It has been manufactured on a commercial basis for nearly 27 years. The first manganese steel castings made in the United States were produced in 1892. Originally it was considered impossible to make manganese steel castings successfully weighing over a few hundred pounds, but at the present time large rolling mill pinions, crusher heads, and similar castings weighing up to 30,000 pounds each are being produced regularly and it does not appear that the limit of weight has been reached by a considerable margin.

Manganese steel possesses remarkable resistance to abrasive wear. It has the peculiar properties of extreme toughness and

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Note: All photographs and subject matter contained in this article pertain to equipment and the practices of the American Manganese Steel Company, of Chicago.

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*Class of 1915-1916.

hardness combined with ability to absorb severe shocks and impacts. It is used extensively for wearing parts of machinery subjected to extreme wear and abrasion where durability is of prime importance. Resultant economy is effected by reason of its long life, elimination of labor connected with renewals, and the expense incident to shut-downs.

A Great Variety of Uses

Manganese steel castings are used for a great variety of purposes, including parts for steam shovels, crushers, dredges, grab buckets, rolling mill machinery, copper converters, stamp mills, ball mills, clay mills, Chilian mills, cement kilns, asphalt presses, brick and tile machinery, coal mining and breaking machinery, concrete mixers, traveling cranes, lifting magnates, and gears. Manganese steel is also employed for the manufacture of safes, railway frogs and crossings, foundry tumbling barrels, and many other things of like nature.

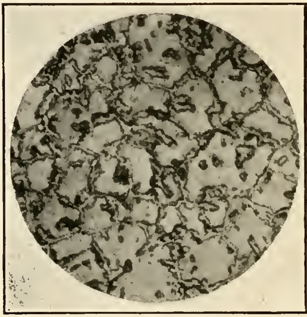

Fig. 1—Microstructure of Cast Manganese Steel Untreated, Magnified 100 Diameters

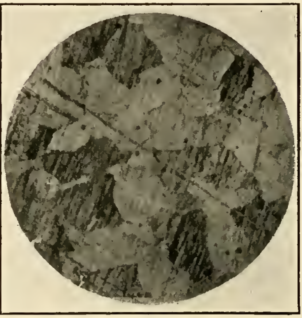

Fig. 2—Microstructure of Cast Manganese Steel Properly Heated, Magnified 100 Diameters

Although fundamentally similar to ordinary steel foundry practice, the successful production of manganese steel castings involves a number of factors not vital in ordinary work. As manufactured at present, manganese steel is similar in analysis to ordinary converter metal except that it is high in carbon and unusually high in manganese. In ordinary commercial castings the proportion of manganese ranges from 11 to 13½ per cent.

This combination of elements gives the finished castings certain distinctive metallographic and physical qualities, which will be detailed later. As manganese steel comes from the sand it is almost glass hard and brittle. It must be made ductile by an annealing or heat-treating process. The heat treatment is a very essential part of the process and must be properly manipulated to insure satisfactory results.

The necessity for heat treatment limits the thickness of section which it is possible to cast successfully with manganese steel. Originally the castings were made with comparatively thin sections, but researches carried on during the past few years by prominent manufacturers have resulted in a gradual increase in the thickness of section that it is possible to treat successfully, until at present, castings with walls up to 5½ inches in thickness are handled satisfactorily. Heavy castings are cored out to a minimum thickness of 5½ inches. This not only serves to eliminate the internal stresses which invariably are set up in a very thick casting, but also reduces the weight and inertia of the piece, an important consideration if the casting is a moving part in a machine. At the same time, the maximum allowable heat-treating thickness of 5½ inches is sufficient to permit the use of manganese steel for the heaviest classes of machinery. It is evident from the foregoing that although manganese steel is made in a converter and cast in sand molds, the process is by no means a simple one. The manganese steel founder is confronted with all of the problems of the ordinary steel foundryman, plus a host of special complications arising from the peculiar physical and chemical characteristics of the material with which he is working. In order to achieve success it is necessary to have special experience all along the line, particularly with reference to melting and mixing the metals and heat-treating the castings.

Physical Characteristics

The early papers of Sir Robert Hadfield mentioned tensile tests of specimens of manganese steel showing an ultimate strength of approximately 100,000 pounds per square inch with elongations as high as 40 per cent. In some instances an ultimate strength of 150,000 pounds per square inch is mentioned by him. That the physical characteristics of manganese steel are superior to many high grade steels is indicated by the following average figures taken from numerous tests made by the American Manganese Steel Company. They are to be viewed only as relative values by way of comparison rather than for exact laboratory detail. Tensile strength from 90,000 to 110,000 pounds per square inch; elastic limit about 50,000 pounds per square inch; elongation in 2 inches about 33 per cent; reduction of area about 35 per cent.

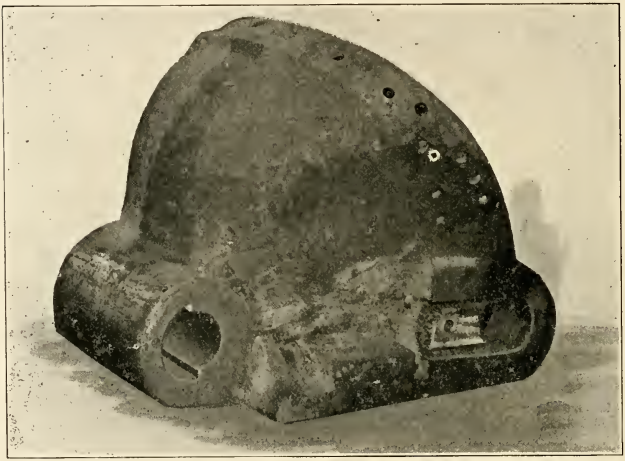

Fig. 3—Early Design of Dredge Bucket Showing Sharp Corners in Back Eye

Manganese steel does not owe its wear resisting qualities to its hardness. When subjected to the Brinell test it shows an average hardness number of about 200. The extreme outer fibre of the treated steel shows a slightly lower hardness number than at a depth of about ⅛-inch. From the latter point the hardness remains constant to the core of the casting. The lowering of the hardness at the surface is due to the oxidation of the carbon which forms on the surface during the heat treatment. The toughness of the material is due to its great molecular cohesion which causes the particles to flow rather than to tear off. When tested with a scleroscope, manganese steel shows a hardness of from 40 to 50.

The specific heat ranges from 0.145 at ordinary temperature to about 0.20 at 1200 degrees Centrigrade. Between ordinary atmospheric temperatures and 600 degrees Centrigrade, the heat conductivity appears to be about one-third that of low carbon steel. The specific gravity of manganese steel ingots is nearly the same as the result obtained by the usual method of determining specific gravity with a chemical balance, using a small specimen of cast steel. The rolled steel is slightly heavier than the cast material.

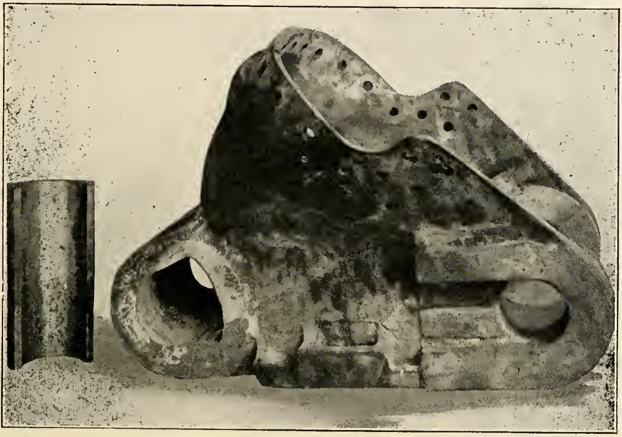

Fig. 4—Present Design of Dredge Bucket with Corners in Back Eye Eliminated (Patented)

The electrical resistance of manganese steel is approximately 3.4 times the resistance of ordinary Bessemer steel. At temperatures between 100 and 600 degrees Centrigrade electrical resistance is said to remain practically constant. Manganese steel is non-magnetic and advantage is taken of this property in the use of this material for shields or bottom plates of lifting magnets, such as are extensively employed in foundries.

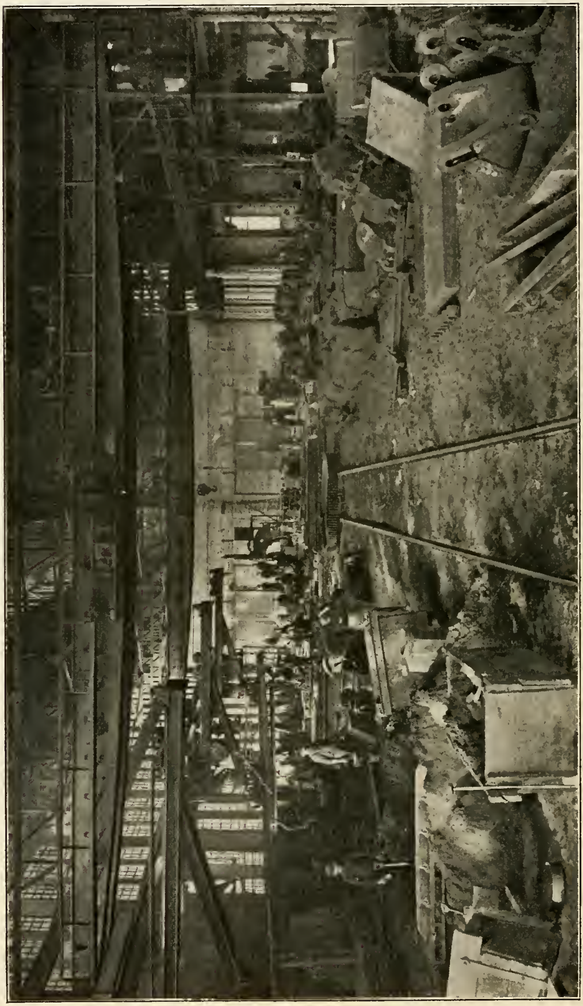

Fig. 5—General View of Molding Floor, West Bay at Chicago Heights Plant. Note Extensive Crane Equipment

The shrinkage of manganese steel is excessive, amounting to 5/16-inch per foot as against 3/16-inch to 1/4-inch in ordinary steel foundry practice. The high shrinkage creates a number of foundry problems which will be discussed in some detail later.

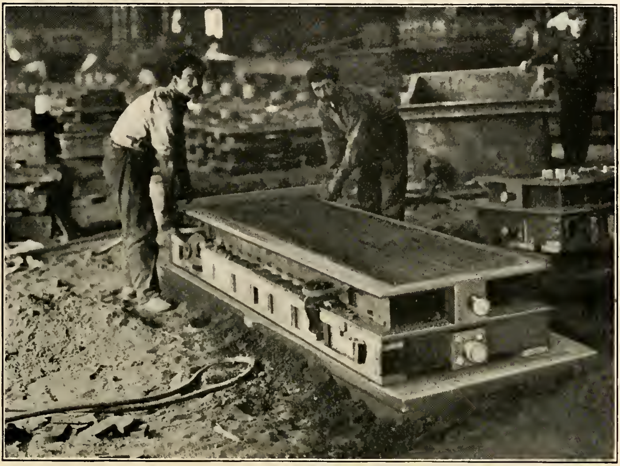

Fig. 6—Molding Guard Rails on a Pneumatic Jarring Machine

Chemically, cast manganese steel has the following composition:

	Per cent
Carbon	1.25
Silicon	0.30
Manganese	12.50
Sulphur, less than	0.02
Phosphorus, about	0.08

The distinctive characteristics of manganese steel are clearly delineated by the microscope. It is well known that manganese is present in all ordinary steel, but the metal does not become austenitic until about 6 per cent manganese and 0.80 per cent

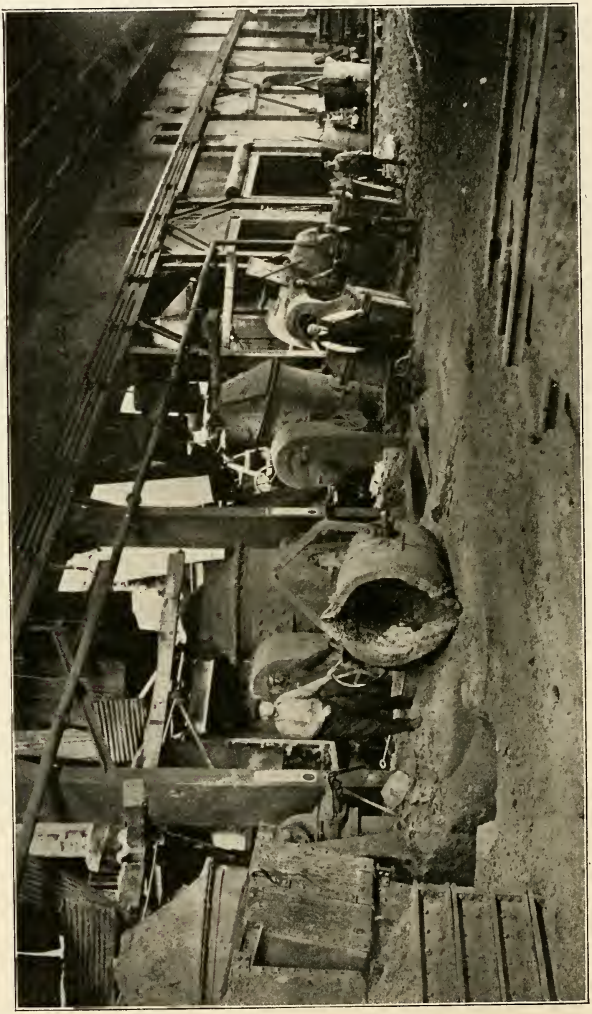

Fig. 7—Converter Equipment, Chicago Heights Plant

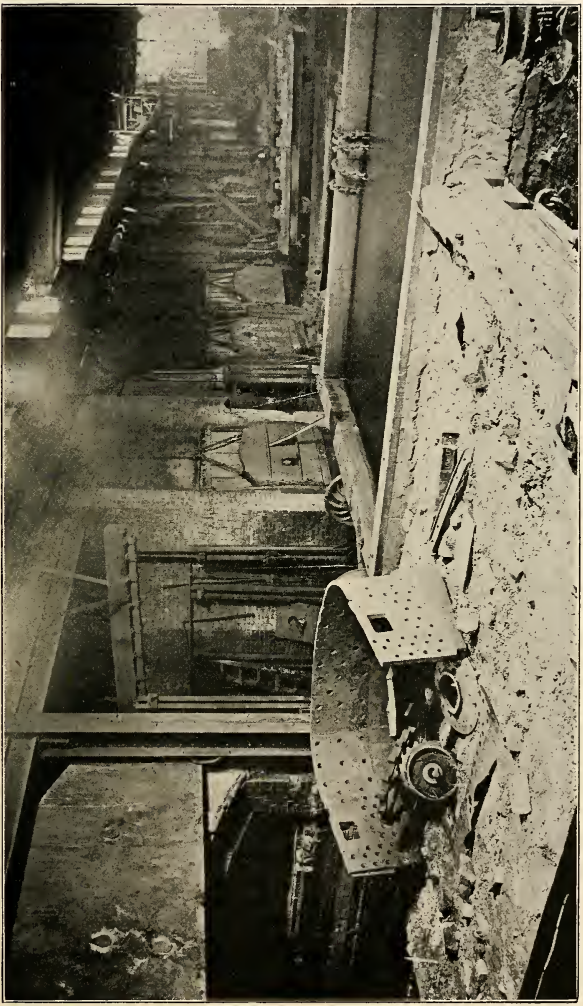

Fig. 8—Heat-Treating Furnaces with Tanks for Quenching Castings, Chicago Heights Plant

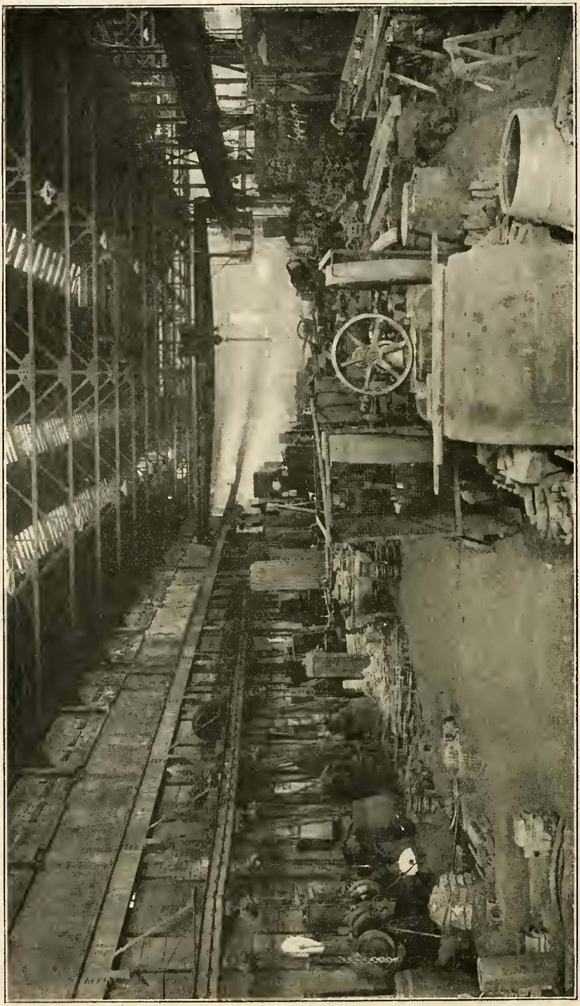

Fig. 9—East Bay of Cleaning Room, Chicago Heights Plant

carbon are introduced. Commercial manganese steel generally contains from 11 to 13½ per cent manganese and from 1.00 to 1.30 per cent carbon.

Proper Structure Can Be Determined

In the cast state the metal is composed principally of austenite and free cementite, austenite being a solution of iron, manganese, and carbide of iron and manganese, while free cementite is composed of the carbide of iron and manganese which remain undissolved. Free cementite is very hard and brittle and therefore manganese steel is also very brittle in the cast condition. However, upon receiving a proper heat treatment all of the free cementite is dissolved forming austenite which is known to be very ductile and to present a high resistance to wear. This is a metallographic explanation of the chief characteristics of manganese steel. In order to obtain the austenitic structure it is necessary that the steel be given a correct treatment. Microscopic examination reveals the fact that if the steel is heated to a proper temperature and quenched in water, it is composed entirely of austenite. By the aid of the microscope, therefore, the proper structure can be determined and together with physical tests and chemical analysis most excellent results are obtained.

The accompanying microphotographs, Fig. 1 and Fig. 2, show the structures of manganese steel as cast and after treatment, magnified 100 diameters. Fig. 1 shows the structure of manganese steel in the cast condition. Fig. 2 shows the same steel heated to a temperature of 1800 degrees Fahrenheit and quenched in water. It will be noted that since the heat treatment is correct, all of the free cementite has disappeared leaving a purely austenitic structure. If the steel is again heated to over 700 degrees Fahrenheit the pure austenitic structure is destroyed, seriously injuring the quality of the metal. It, therefore, is imperative that manganese steel should not be heated to a temperature exceeding 700 degrees Fahrenheit after leaving the foundry where it was manufactured.

Casting Design Details

Owing to shrinkage difficulties and to the problems con-

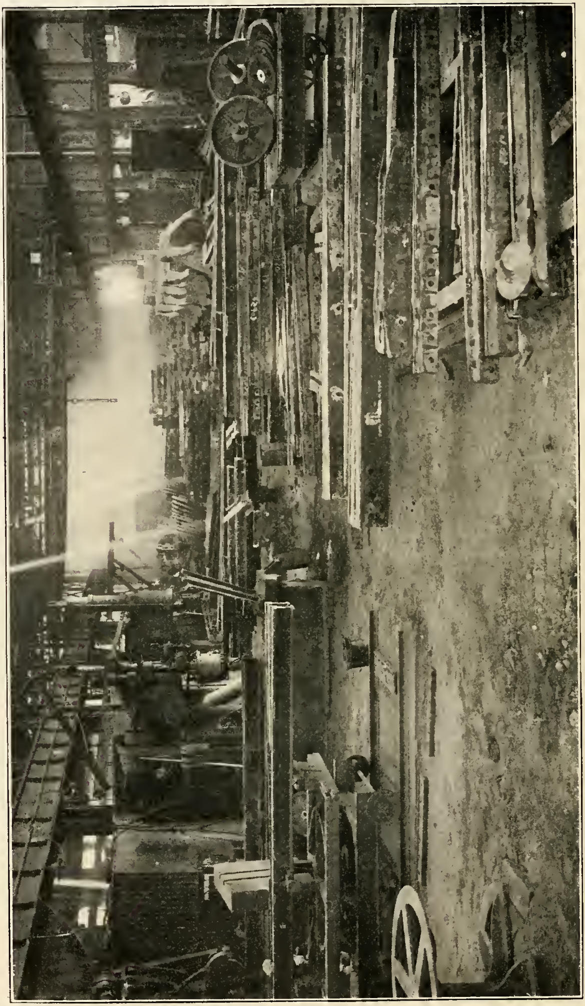

Fig. 10—West Bay of Cleaning Room, Chicago Heights Plant

nected with annealing, it is necessary, in order to achieve success in the manufacture of manganese steel castings, to start with the design of the parts. A few simple changes in design may spell the difference between success and failure in the foundry. It is necessary for the designer, however, to have a thorough knowledge of the peculiarities of the metal. The importance of correct design is very clearly indicated by the dredge buckets shown in Figs. 3 and 4. The original type of bucket is shown in Fig. 3 and the improved patented design in Fig. 4. In Fig.3 it will be noted that there are two square corners in the back eye. In this design the bushing, with which the eye is fitted, bears on the shoulders created by the two sharp corners previously mentioned. Although these corners were provided with a small fillet it was found extremely difficult to insure perfectly sound metal at this point. As a result, the bucket was apt to fail at one of the points of greatest stress.

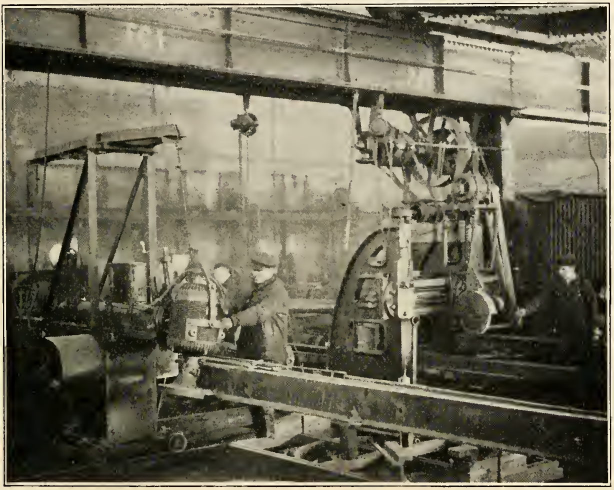

Fig. 11—Grinding Track Work

In the improved design shown in Fig. 4, it will be noted that

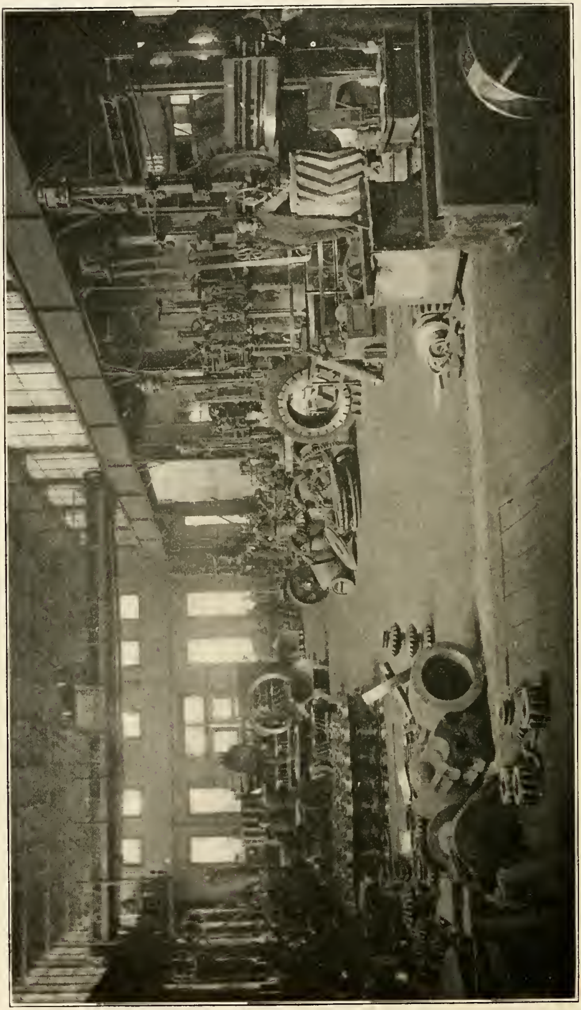

Fig. 12—North End, Main Bay of Machine Shop, Chicago Heights Plant

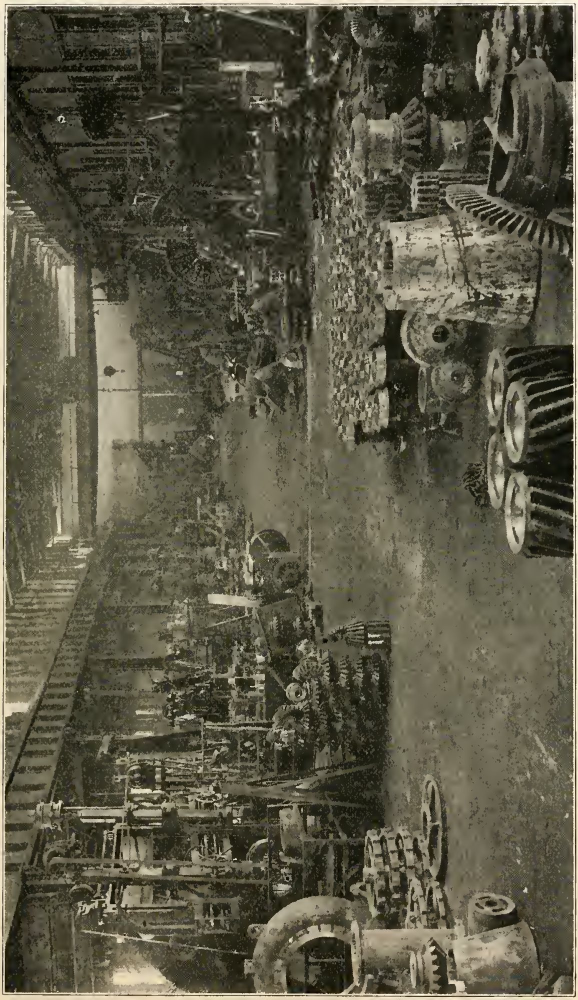

Fig. 13—South End, Main Bay of Machine Shop, Chicago Heights Plant

the two square corners have been entirely eliminated resulting in a much more satisfactory job from a foundryman's standpoint. Fig. 4 not only shows the new form of the back eye but also illustrates the bushing with which the eye is fitted. Generally speaking it is more necessary to avoid an abrupt change in section and sharp corners when making manganese steel than when turning out ordinary low carbon steel castings.

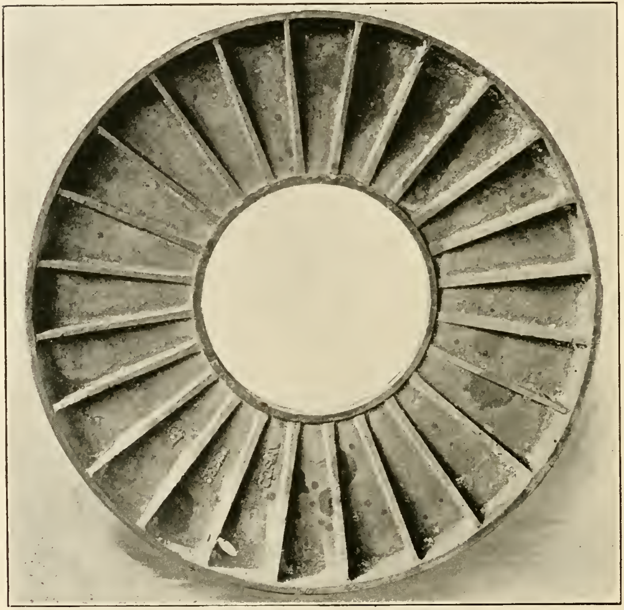

Fig. 14—Coil Shield for Lifting Magnet

It is essential that the pattern be provided with the proper shrinkage allowances, which are not confined simply to the dimensions of the pattern, but also include the distribution of the metal in the casting.

At times it is necessary to add metal to a casting temporarily to withstand shrinkage strains; such additions of metal are removed in the machine shop by grinding before the casting is shipped. In handling work of this character, unusual skill is necessary in order to properly allow for shrinkage stresses.

While a majority of the patterns used are made of wood, it has been found advantageous to use metal where great durability is required, as in ordinary practice. The pattern shop at the Chicago Heights plant is provided with band saws, circular saws, woodworking lathes, and boring and mortising machines, together with other equipment for the rapid and economical production of patterns.

Founding

A molding floor of the Chicago Heights plant is shown in Fig. 5. It will be observed that the crane equipment is extensive including heavy electric traveling cranes which span the entire floor, supplemented by wall cranes. In making molds, it has been found that ordinary molding sand and clay binders are unsatisfactory on account of the cutting action of the molten metal. Sands with a high percentage of silica are used and most of the molds are oven dried. Special facing mixtures are required owing to the crushing effect of the shrinking manganese steel. An open facing which will yield readily is necessary, but at the same time sufficient skin hardness to prevent the mold from being washed away is required. Similar diffiiculties are encountered in providing proper core sand mixtures. These mixtures must be free venting; they must have sufficient strength to stand up properly under the destructive action of the molten metal and at the same time the core must yield readily when the casting commences to shrink. Extensive experiments have been conducted enabling the determination of proper mixtures for facings and core sand, and to the development of standard formulas.

For the economical production of heavy molds, jar ramming machines are used to advantage as in ordinary steel foundries. Guard rails are made on a pneumatic jarring machine. This machine which is illustrated in Fig. 6 is provided with a table 3 feet 4 inches wide and 10 feet 4 inches long. The molds are made in cast-iron flakes, 9 feet 9 inches long and 2 feet wide, both the copes and the drags being rammed on the machine. The patterns are mounted on a follow board. The copes are barred, gaggered, and rammed right side up with the pattern underneath, a green sand core extending from the cope into the drag portion of the mold. Fig. 6 shows a drag on the machine just after it has been rammed and struck off. Before being rolled over it is provided with a heavy cast-iron bottom board. The guard rail castings are each about 8 feet long and six men turn out about 30 molds a day. The molds are poured two-up with a large and a small ladle. Each mold is provided with a 1½-inch riser in the middle. Other methods are employed in molding other castings. The rolling mill pinions, Fig. 21, for instance, are molded vertically in a four part flask

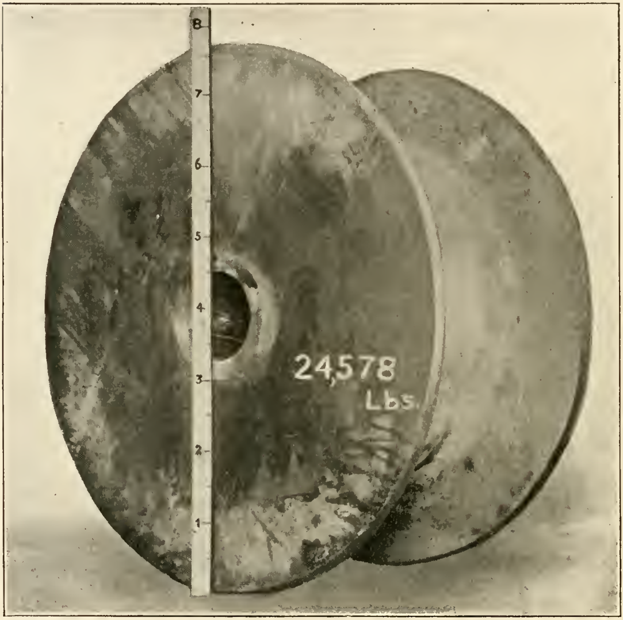

Fig. 15—Manganese Steel Dredge Tumbler Weighing 24,578 Pounds

provided with goose neck gates. In this case the metal enters from the bottom. Large shrink heads are necessary and it also is essential that the molds be arranged so that the casting may be fed properly during the cooling period.

Preparation of Steel—How Melted and Converted

Manganese steel is a special converter metal, to which a quantity of ferro-manganese is added in the ladle.

The process consists of melting a calculated charge mixture in a cupola, transferring the metal to a converter and its conversion to steel therein. The ferro-manganese which is handled separately, is melted and placed in the bottom of the ladle and the steel from the converter is poured in on top.

At the Chicago Heights plant two cupolas are provided in conjunction with four three-ton converters of the standard side blow type, illustrated in Fig. 7. The cupolas are situated on a mezzanine floor behind the converters and are so arranged that the metal may be drained directly from the cupola spouts into the converters. The ladle and crane equipment is similar to that found in the average steel foundry handling heavy work.

Standard 80 per cent. ferro-manganese is employed and it is necessary to provide suitable facilities for melting this material. For this purpose either crucibles or specially designed reverberatory furnaces may be employed. If the latter method is used, considerable experience is required to design the furnace properly and to operate it successfully. The reverberatory furnace, however, has certain advantages over the crucible method, inasmuch as under proper conditions the labor cost is much less. The working conditions in the furnace room also are less severe and the cost of crucibles, no small item at the present time, is eliminated.

Enough ferro-manganese is used so that the castings will show about 12½ per cent manganese when analyzed. This is an average figure; the exact quantity of manganese varies somewhat with the nature of the work. The manganese acts as a strong scavenger, removing the gases and impurities from the metal, leaving it condensed and homogeneous. The production of slag is excessive and before the molds are poured the ladles are allowed to stand for a time in order to permit the alloy to perform its function and also to skim off the slag. The raw materials used in the production of the converter metal include low-phosphorus pig iron and selected steel scrap, similar to those used in the ordinary Bessemer steel foundry. The same careful selection is necessary to insure uniformity in the finished product. The metal is handled and poured while very hot.

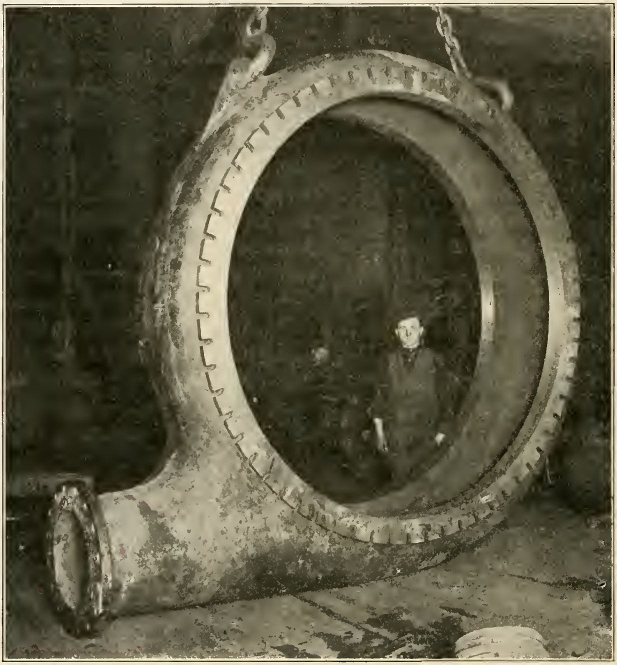

Fig. 16—Centrifugal Dredge Pump Shell, 20-Inch Discharge Pipe, Diameter 10 Feet, Weight 15,222 Pounds

As previously mentioned, when the castings come from the sand they are glass hard and before they are suitable for use they must be annealed. For this purpose furnaces of the proper size in which the temperature may be readily controlled are necessary, together with quenching tanks and suitable crane equipment for handling the hot castings. The annealing furnaces are of the ordinary open-flue type. Usually they are provided with cars on which the castings are placed for the heat-treating process. It is essential that as little time as possible elapse between the moment when the furnace door is opened and that when the casting is immersed in the quenching tank. It is, therefore, desirable to locate the tanks directly in front of the annealing furnaces as shown in Fig. 8.

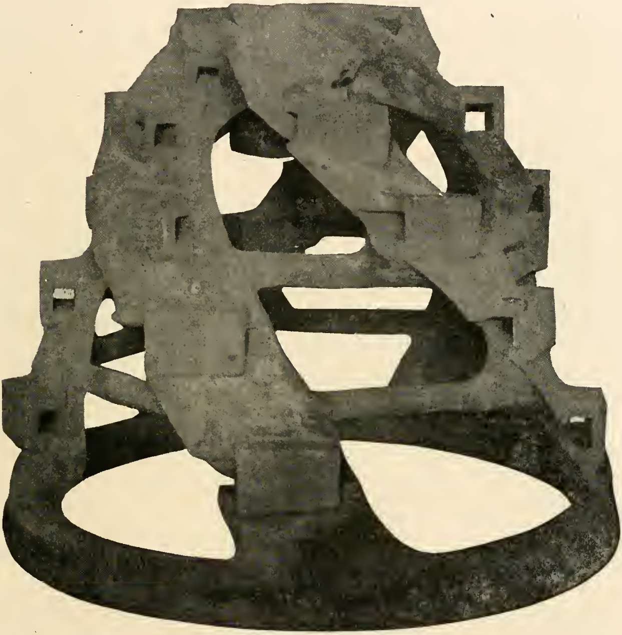

Fig. 17—Cutter Head for 20-Inch Suction Dredge. Height 5 Feet 2 Inches, Diameter at Bottom 6 Feet 1¾ Inches, Weight 7,375 Pounds

Some Details of Heat Treatment

In discussing the heat treatment of manganese steel, W. S. Potter, in a paper presented before the Western Society of Engineers, at Chicago, on February 17, 1909, makes the following interesting statements:

"Upward of 75 years ago men in Sheffield, England, understood that steel containing moderate additions of manganese had certain properties which could be described as those of carbon steel, and that steels containing a higher percentage than 5 per cent. or 5½ per cent. were very weak and brittle.

"Some 30 years ago, the Hadfields, father and son, or their associates, found, and the son advertised, the fact that castings and forgings containing the higher percentages of manganese, after heating to a high temperature and quenching in water, were very strong and tough and that the treated steel had remarkable resistance to abrasive wear. The proportion of manganese mentioned as suitable for track-work castings, in Hadfield's early patents is 11 per cent. No heat treatment was mentioned in the early papers, but later a treatment was announced and consisted in heating the casting at first slowly and then rapidly to 800 degrees, 900 degrees, or 1,000 degrees Centigrade, and immediately quenching in water. No theory covering the necessity of this reheating and quenching was given.

"Manganese steel of ordinary composition poured in a layer about ¼-inch to ½-inch thick in a chill mold will, when cold, bend double, and has all the usual toughness of reheated and quenched manganese steel. Castings from the same ladle of steel poured in sand molds have a toughness approximating the toughness of the reheated and quenched metal in inverse proportion to the thickness of the sand-cast section. For example, a sand-cast section ½-inch thick will usually bend from 45 degrees to 90 degrees before it breaks by cold bending. A section 2 inches thick usually breaks in cold bending before it is deflected as much as 20 degrees. The thinner section is whiter and has smaller crystals than the heavy sand-cast section, and the chill-cast section is still whiter and has still smaller crystals than the thin sand-cast section. If the three specimens are heated to 1,000 degrees Centigrade and quenched in water they will exhibit in each case a very remarkable and practically equal degree of toughness. In all these cases the steel has practically the same hardness. The chill-cast specimen, before reheating, is the hardest; the sand-cast specimens are the softest. If the specimens are now heated to 700 degrees Centigrade or even a little lower temperature, held for, say one-half hour at this temperature, and cooled slowly to ordinary temperture and broken, they are surprisingly weak, and as a rule, bend but slightly before breaking. The crystals are very large and it is obvious that no strong cementing materials are present to bond the crystals. A section 3 inches thick cooled slowly from the heat of casting, and put under a drop weight will break about as readily as an equal thickness of a fair quality of gray iron and will frequently show crystals with a mirror surface as large as 1¼ by 1 inch. For the most part such a section so treated and broken will show crystals about ¼-inch to ⅜-inch on a side. A specimen heated to above 700 degrees Centigrade and cooled slowly to below 600 degrees Centigrade is very weak. If this specimen is reheated to 700 degrees Centigrade, and quenched in water, only a slight increase in toughness is noted. The crystals are still apparently as large as ever. The bond between the crystals is almost as weak as before, and yet from the other tests it is clear that the steel

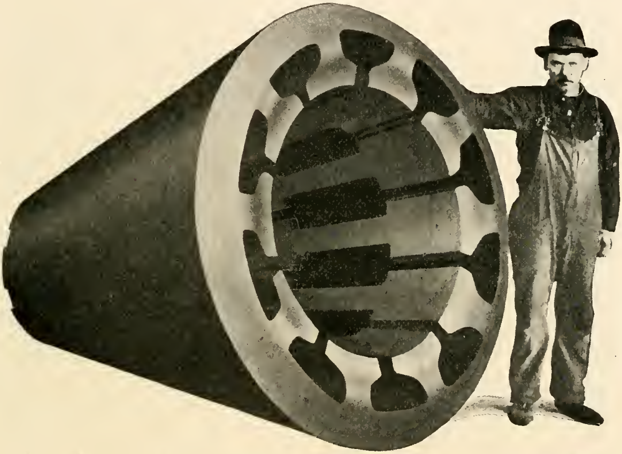

Fig. 18—A Black Ventilated Head (Patented) for a No. 21 Crusher, Weight 21,350 Pounds

crystalizes or re-crystalizes considerably below 700 degrees Centigrade.

"Comparing this steel with a carbon steel it is obvious that the cementing materials are not taken into solution at as low a heat in the manganese steel as in the carbon steel. In the carbon steel, the size of crystals, strength, toughness, etc., may be redetermined any number of times by reheating to 700 degrees Centigrade and cooling, and as is well known, the physical properties are governed by the rate of cooling.

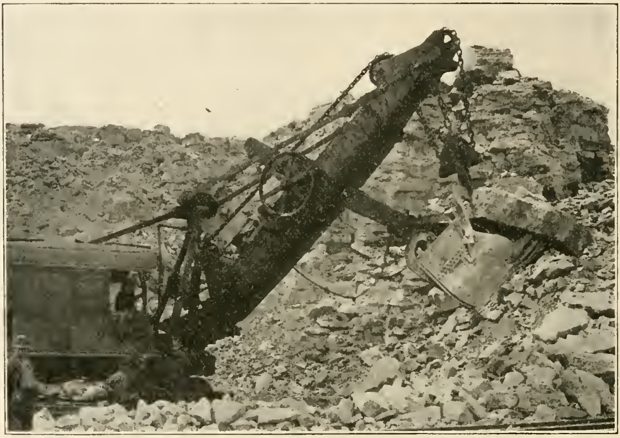

Fig. 19—3½-Yard "Missabe" Dipper (Patented) in Hard Service Digging

"The manganese steel after being put in a weak condition due slow cooling from 700 degrees or above is only put in a condition of maximum toughness by reheating to a much higher temperature and then cooling rapidly enough to prevent either mechanical or chemical separation.

"A comparison of color carbon tests with determinations of total carbon by combustion, shows that the slow cooled steel has a much smaller amount of carbon in the condition which permits of the determination of carbon by color than the manganese steel which has been rapidly cooled. The highest color result is obtained from the thin chill-cast section, the next highest from a specimen heated for a short time only and quenched in water. The lowest carbon result (by color test) is found in the specimen which has been heated to a high temperature, maintained at this temperature for some time and cooled very slowly. The chill-cast specimen showing by total carbon determination 110 points carbon, by color test may show 105 to 108 points. The specimen annealed at a high heat will give color results ranging from 0.60 to 0.95 per cent., depending upon the time to which the specimen was exposed to the highest temperature, the rate of cooling, and the percentages of manganese and silicon.

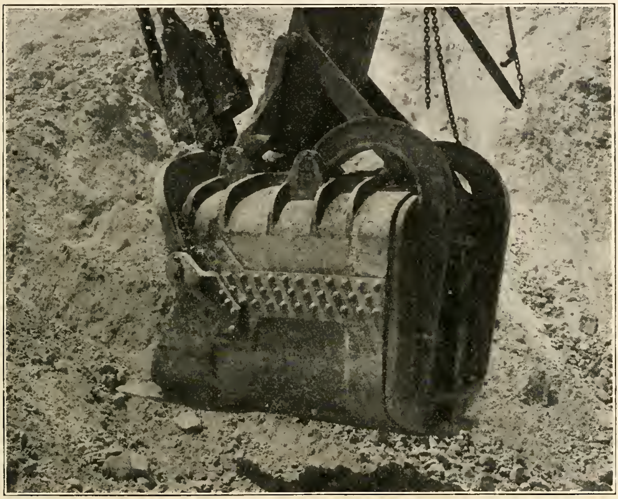

Fig. 20—Close Up View of a 3½ Yard "Missabe" Dipper in Copper Ore Digging

"As might be anticipated from the general knowledge pertaining to the art of 'black heart' malleable iron manufacture, the percentage of silicon plays a very important part in the decomposition of carbides of iron and manganese in manganese steel.

"Manganese steel is readily burned when heated, and this burning is more difficult to avoid as the temperature is higher. For this reason it is usual to heat for quenching only to a point suffiiciently high to give the characteristic toughness in the quenched metal.

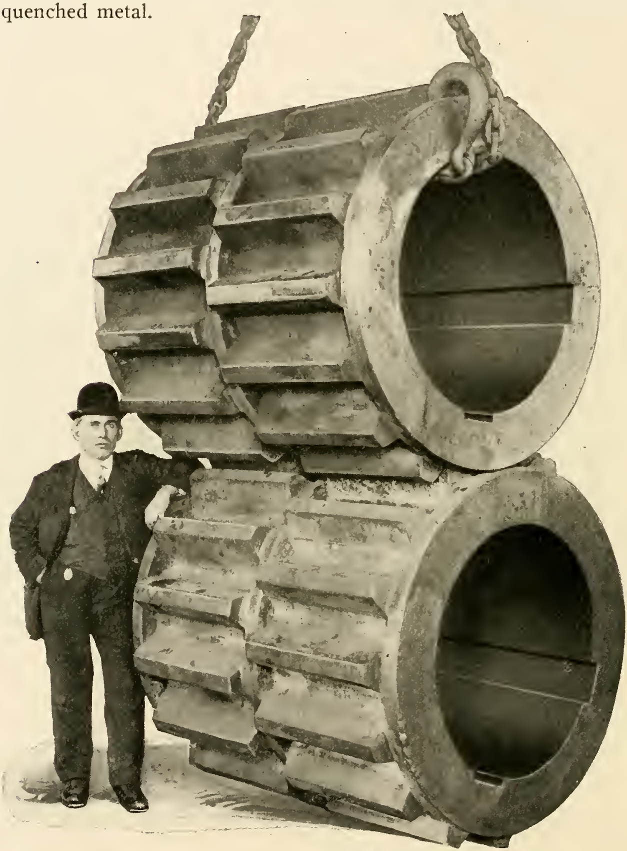

Fig. 21—52 Inch Blooming Mill Pinions

"If castings or other finished shapes are reheated for toughening to a high temperature they are apt to be very generally affected with deep cracks. To avoid burning and cracking the reheating is generally stopped at about 1000 degrees Centigrade."

In operating the annealing ovens or furnaces it is necessary to heat the castings up slowly so as not to create expansion strains which will cause cracks. If the castings are heated rapidly the outside, of course heats faster than the core, resulting in internal stresses of a serious nature. After the proper annealing temperature is reached, from 1600 to 2200 degrees Fahrenheit, the castings must be given a soaking heat for several hours in order to bring the molecules into a state of equilibrium. The time required for this operation varies from 4 to 24 hours depending on the size and character of the casting. As previously stated, the thickness of the metal which can be successfully annealed has gradually been increased until now castings with walls 5½ inches thick are handled without any great difficulty. It is advisable to have the water in the quenching tanks as cold as possible in order to cool the castings quickly, before there is any time for internal structural changes. The men drawing the castings from the annealing furnaces must be protected from the heat with special clothing and helmets. Respirators also are desirable owing to the noxious gases emitted from the furnace when the door is opened.

Not Easily Cleaned

The proper cleaning of manganese steel castings presents many problems in itself. Very little sand adhers after the casting comes from the quenching bath. The metal is so tough, however, that practically all of the trimming operations must be conducted by grinding. Extensive portable, electrically-driven grinding equipment is necessary for this purpose. Two views of portions of the grinding and cleaning rooms at the Chicago Heights plant are shown in Figs. 9 and 10. The method of grinding track work is shown clearly in Fig. 11; at the right is a planer for surface grinding and at the left is a special grinder for grinding fishings. It will be noticed that a heavy investment is required in order to properly equip these portions of the plants.

Machining

Extensive machine shop equipment is maintained in connection with the work. Figs. 12 and 13 show several views of the main machine shop at the Chicago Heights plant. Where castings are to be finished in any way, ordinary machining methods are unsuccessful and grinding must be resorted to, necessitating special equipment. Holes, more than 1¼ inches in diameter, are cored out of the castings and ground to size with special wheels. When it is necessary to drill smaller holes or to cut threads, soft steel or wrought iron inserts are set in the molds at the desired points like chaplets and the metal is cast around them. Incidentally this adds to the difficulties of the foundryman. Sometimes bushings are set in the hubs of gear wheels when it is desired to machine them by ordinary methods. Liberal allowances of metal are made for grinding in order to minimize the danger of spoiling the work in the machine shop.

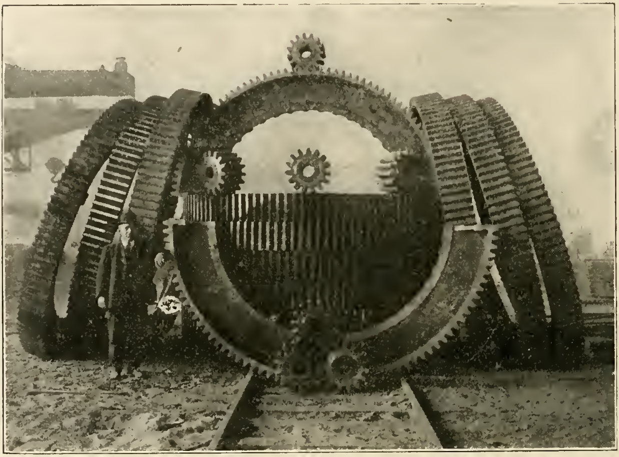

Fig. 22—Tube Mill Gears and Pinions

It is necessary for the machine shop foreman to exercise his judgment continually; coarse wheels and heavy cuts are used so that the metal is removed rapidly, although by no means as easily as would be the case were it possible to employ ordinary cutting tools.

Some of the Uses for Manganese Steel

Some mention already has been made of the purposes for which manganese steel is used. In the foundry, manganese steel is used for the linings for tumbling mills as well as for gears, crane wheels, elevator buckets, grab buckets, lifting magnet shields, etc. This material is particularly desirable for lining tumbling mills owing to its extreme resistance to abrasion.

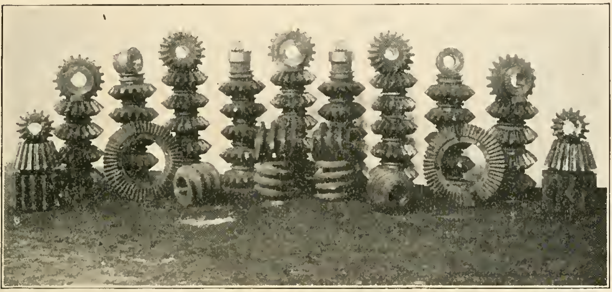

Fig. 23—Group of Miscellaneous Small Gears

Manganese steel has advantages for crane wheels where uniform diameters must be maintained on the drives to insure straight alignment in travel. A microscopic examination of a manganese steel wheel under load will show a flat spot instead of a line contact as in the case of hard metal wheels. Manganese steel under these conditions is springy and recoils as the load is released. About 30,000 pounds always has been considered a safe working load on chilled iron wheels for this purpose. Manganese steel crane wheels, however, are in successful use with rolling loads of 90,000 pounds per wheel.

A large centrifugal dredge pump shell is shown in Fig. 16. It is 10 feet in diameter and weighs 15,222 pounds. Manganese steel is fast becoming recognized as the metal for use in dredge, sand and gravel producer work because of its superior wearing qualities. Fig. 17 shows a large cutter head for use on a 20-inch suction dredge operated by the United States Government. It is one of the most difficult castings that has been made in manganese steel. The diameter at the base is 6 feet 1¾ inches, the height 5 feet 2 inches, and the weight 7,375 pounds.

The Black Ventilated crusher head (patented) shown in Fig. 18 is a one-piece head, and as the name implies, has a series of vertical flues, or cores, running from top to bottom, which permit a circulation of air between the wearing surface and the shaft. This feature prevents the transmission of the heat incident to crushing, from the wearing surface to the shaft.

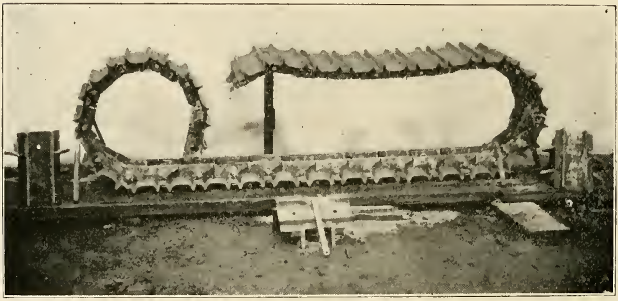

Fig. 24—Tractor (Caterpillar Type) Track Work

By reason of the great resistence of the casting, practically complete absorption of the shock incident to crushing is realized, resulting in increased crushing efficiency and slower destruction of the wearing surface. These heads are found to be especially successful in crushers of large size.

For crusher parts such as heads, concaves, and jaw plates, manganese steel wears from four to six times as long as chilled iron and does not chip or pocket.

The value of manganese steel was early recognized in its use for dipper teeth. Now entire dippers as well as various other steam shovel parts, such as sheaves, dipper stick racks and pinions, are made of this steel. Fig. 19 shows a 3½ yard

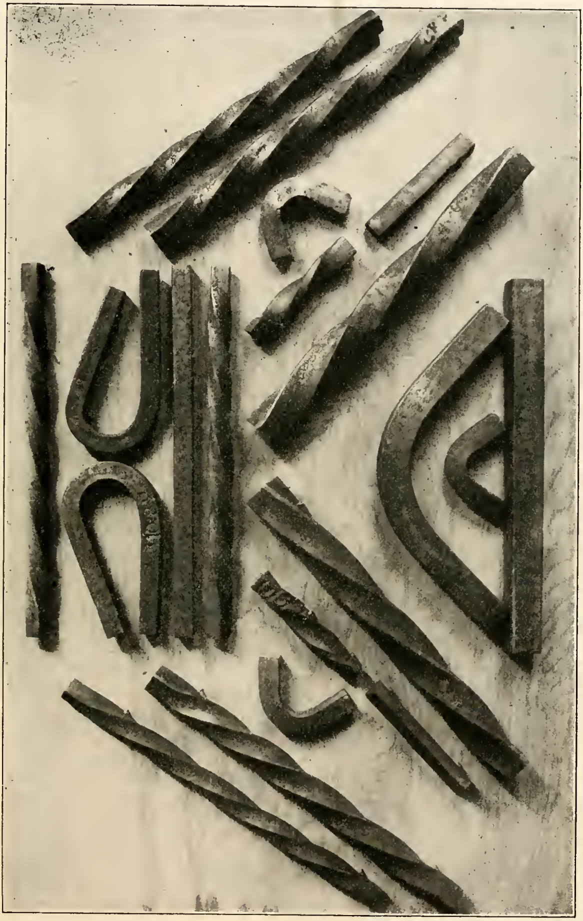

Fig. 25—Manganese Steel Test Bars Bent and Twisted Cold

"Missabe" dipper (patented) made complete with the exception of the rivets, of manganese steel. A feature of this dipper is the front shown, known as the Vanderhoef type (patented) eliminating the use of cumbersome tooth bases. The bases are cast integral with the front. Short reversible tooth points are employed which can be easily renewed. Fig. 20 is a close up view of a 3½ yard "Missabe" dipper used for digging copper ore in Nevada.

Manganese steel also is extensively employed in the manufacture of rolling mill machinery. It has been found particularly suitable for the pinions on heavy roughing and blooming mills. A set of typical rolling mill pinions made of cast manganese steel are shown in Fig. 21. These pinions are cored out to a maximum thickness of 5½ inches. Many other machine parts around steel mills are now being made of manganese steel including pipe drawing balls, chafing plates, sprockets, cams, draw chains, unloader chains, conveyor chains and buckets, screens, and the like.

When gears and pinions made of manganese steel are subjected to heavy wear, much trouble due to breakage is eliminated because the steel in this application seldom breaks and is remarkably long-lived. Some large tube mill gears and pinions are shown in Fig. 22. A group of miscellaneous small gears is shown in Fig. 23.

Fig. 24 shows the application of manganese steel to tractor (caterpillar type) track work.

A good illustration of the remarkable toughness of this metal is indicated in Fig. 25. The cast test pieces shown were bent and twisted cold.

THE FIELD OF FIRE PREVENTION AND FIRE PROTECTION ENGINEERING.

BY N. F. KIMBALL

Instructor of Fire Protection Engineering, Armour Institute of Technology.

Imagine a street extending from Chicago to New York lined with all kinds of buildings,—dwellings, stores, factories, warehouses, school houses, hotels. Every year a fire starts at one end of such a street and burns clear through to the other end. For every 1000 feet this fire burns—and it burns at the rate of about three miles a day—some person is injured; and for every 4000 feet a human being is burned to death.

This is the annual American bonfire.

The annual fire loss in United States and Canada has averaged a quarter of a billion dollars per year for the past ten years. This means that nearly $700,000 per day, $30,000 per hour, or $500 per minute is contributed to the national ash heap. Every ten minutes the equivalent of a comfortable home valued at $5000 is destroyed.

This waste or loss of $250,000,000 yearly does not include the huge cost of fire departments. That is an additional burden. It is estimated that if the expenditure for the maintenance of fire departments, private fire apparatus, water works for fire extinguishment purposes, and the cost of carrying insurance, the necessity of which is directly caused by fire, be added to the fire losses, the drain on this country on account of fires would amount to nearly $400,000,000 per year.

According to the compilations by the "Journal of Commerce," the fire losses in the United States and Canada for the year 1917 aggregated $267,327,300, the heaviest of any year in the history of the country except 1906, when the great San Francisco conflagration swelled the total to $450,710,000. It is probably true that some proportion of this heavy loss in 1917 is due to the activities of agents of the enemy. Fire has been one of the enemy's main reliances for every fire in United States is a victory for our enemies. Every elevator burned—and one is burned nearly every day—is equal to the sinking of a ship. Doubtless the history of the ingenious and daring plots that have been undertaken, many of which have been successful, if written would make startling reading. Even where the fires have not been incenditory, a good deal of this loss may reasonably be atributed to the hazards due to the strain of increased production. Many factories have been forced to run with shifts of workmen upon a 24-hour schedule; emergency lighting and heating systems have been installed; floors have been crowded with new machines; new buildings have been hastily erected; and the heavy demand for labor has led to the employment of many men who are comparatively unskilled.

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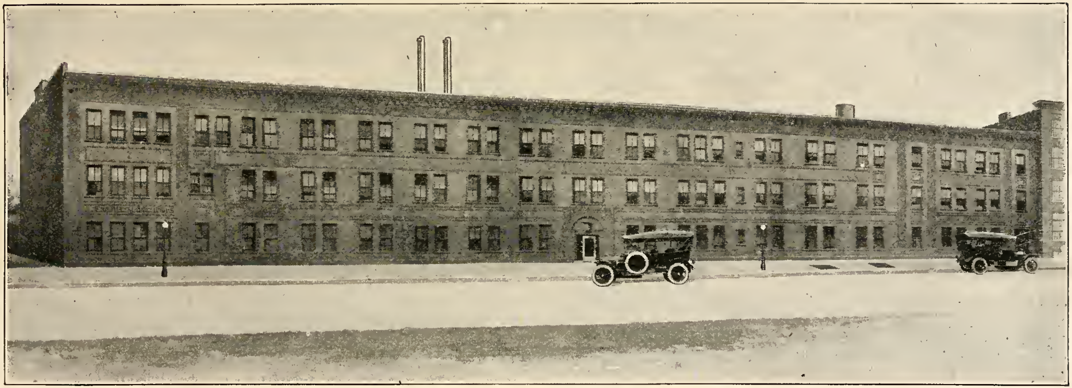
*Class of 1912

In addition to the financial loss, the toll of human life from fire is appalling as evidenced by the fire in the Iroquois Theater of Chicago in which nearly 600 women and children lost their lives; the schoolhouse fire at Collinwood, Ohio, where 165 pupils were either killed or burned; and the Triangle shirt-waist factory fire in New York City in which 145 lives were lost.

In these times a loss of a paltry $250,000,000 a year does not seem of much account in comparison with the billions in which we are now accustomed to think. Neither does the toll of several thousand lives per year compare with the loss caused by the world's war. Nevertheless, even though the national fire waste is dwarfed by the immensity of the waste of war, the fact remains that much could be done especially at these times with a quarter of a billion dollars, yearly.

Now, arises the question, how much of this loss is preventable? Fifty per cent, at least, of the fires are due to preventable causes. In a report of the New York Factory Invesigating Committee testimony was given showing that at least 50 per cent of the fires could be prevented by taking certain simple and inexpensive precautions. Some experts place the percentage of preventable fires as high as 75 per cent and at one time the Chief of the Boston Fire Department, when testifying before the Metropolitan Fire Hazard Commission, stated that in his opinion "at least 85 per cent of all fires are caused through carelessness."

If 50 per cent of the loss due to fire could be prevented, this would mean a saving of $125,000,000 yearly or in ten years of one and one-quarter billion dollars, enough to take care of a good share of the next Liberty Loan.



THE UNDERWRITERS LABORATORIES

The large testing station, maintained by the National Board of Fire Underwriters, where the laboratory work in Fire Protection Engineering is conducted. This building is probably the most completely fire-resistant building in the world.

Though "comparisons are odious" it is still only too true that, before the war at least, the results of American extravagance stand out in marked contrast with the results of European prudence. That losses in buildings and contents can be materially reduced is clearly shown by the experience of these European nations where the universal adoption of "fire prevention" and "fire protection,"—embracing precautionary measures to prevent fires and adequate handling of incipient fires, reduced the losses to a minimum. As shown by the Department of Commerce and Labor the average annual per capita fire loss in six European countries is 33 cents while the average per capita loss in United States is $3 and in Canada $3.07. The annual fire loss of Glasgow, Scotland, is $325,000 while Boston, a smaller city than Glasgow, has an annual fire loss of $2,000,000. The Chicago fire department costs $3,000,000 a year, while in an European city of the same size the cost is but $300,000 a year.

The immunity from fire loss in European countries is not due to better fire protection facilities, but to the fact of better building laws and ordinances, to the enforcement of such, to intelligent efforts at fire prevention and investigation into causes of the fires which take place. The infrequency of large conflagrations in European cities is also primarily due to the prevalence of building of superior construction. While the American cities have been developing for the past twenty years the highest type of fire fighting apparatus, securing large appropriations for their maintenance, and employing a most efficient personnel to use them, European cities have been studying the resistance to fire of the materials of construction, and have taken advantage of the latest knowledge of construction and enacted and rigidly enforced, modern building laws. The fire departments of European cities as compared with those of American cities are ridiculously inadequate, yet the fire loss in European countries is one-sixth of ours. European nations have minimized their fire loss, reduced their insurance tax and cost of living, not by fire fighting, but by fire prevention.

It is not the intention from the above paragraph to convey the impression that fire departments, properly equipped and maintained, are not necessary. Because of the large areas of inflammable buildings, the conflagration hazards are ever present in our cities and large bodies of trained men and large volumes of water are required for their extinguishment. The thought it is desired to convey is that instead of spending so much money to fight fires more should be appropriated to prevent them, for fire prevention has the effect of diminishing the chances of conflagrations by reducing the frequency of fires.

The fire loss, or waste, for it may be termed "waste" since it is a loss which is absolutely irretrievable, is of great importance as it affects the material welfare of the nation as a whole, and is of direct pecuniary interest to each one of us having families to protect and property to preserve for our family's use. It touches the pocket of every man, woman and child, for everything we buy has concealed in its price an amount that is contributed to cover all losses by fire, regardless of cause, whether from misfortune, carelessness, or criminal intention.

The heaviest loss caused by fire in large establishments cannot be measured in terms of money and cannot be recovered from insurance by those who suffer it. It is the loss of time to which the working men and women who are employed in the burned factories, workshops, or warehouses are subjected by a serious fire. This loss of time is often accompanied by loss of tools, clothing and other personal property. It falls upon those who are least able to bear it. The loss of property may be recovered by owners and occupants and the interruption to business and fixed charges, which continue during repairs, can be recovered by those who carry "Use and occupancy" policies of insurance; but the working men and women, who are mainly dependent upon their daily earnings for their daily bread, are forced into the class of the unemployed for weeks or months after every large fire in any large establishment employing great numbers of people.

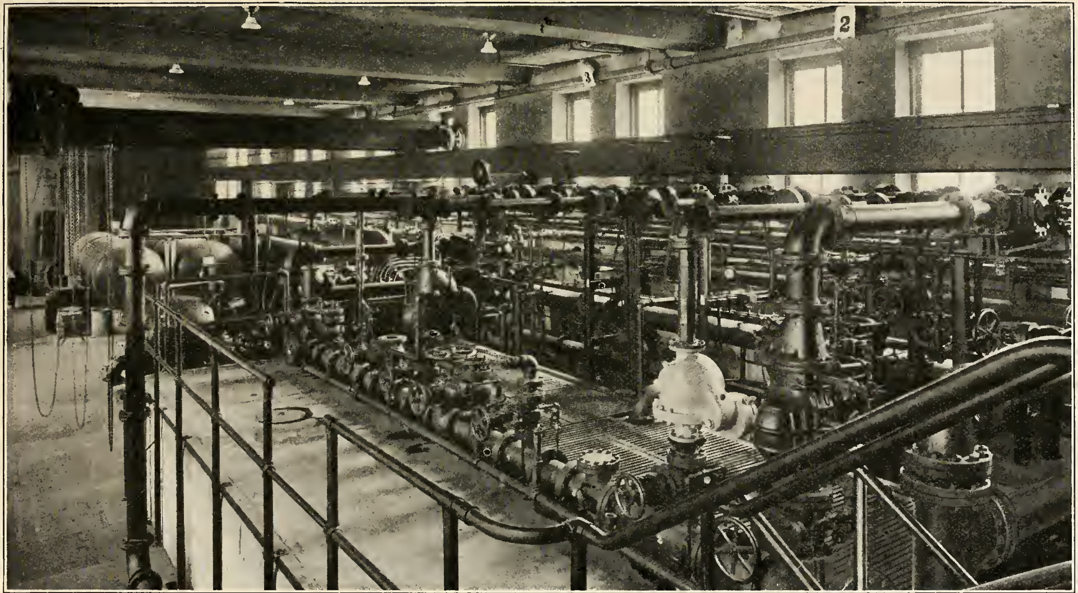
To prevent this waste—to conserve our resources—is the work cut out for the Fire Protection and Fire prevention Engineer.

Fire Prevention, or precautionary measures against fire, deals with the causes of fire, with laws and regulations for preventive safeguards, and with education along this line. The ultimate object of all fire prevention work is the reduction and elimination of conditions causing the spread of fire, and thereby the waste of property and life resulting therefrom, as well as the drain on the nation by the absolute wiping out of property due to its consumption by fire, and the incidental reason, the reduction in fire insurance rates.

Fire Protection, or preservation against loss or injury from fire, deals with the control of fire through proper building construction, by fire departments, and by protective devices and equipments. The two go hand in hand, for while fire prevention is the first line of defense against fire, it does not obviate the necessity for the second line of defense, fire protection. There are so many causes of fires which cannot be foreseen that no system of fire prevention can be devised which would make it desirable for any owner of property to be without adequate fire protection.

The American people have not recognized until the last few years the economic significance of this enormous fire waste nor have they realized until now that our apparently boundless natural resources are limited. However, at the present time "conservation" is a universal slogan and a great deal of thought and attention is being given to the problem. One of the greatest demands made upon science to-day is the effort to conserve our resources and to the economic conditions which govern the success of a manufacturing or mercantile industry, and we might say the whole nation, demand that business shall not be interrupted by fire. Business men are expecting more and more from engineers along this line and the time is now here when the owner and builder demands that in the design and execution of any form of structure means of preventing and protecting the property against fire be thoroughly considered by men trained in this science. The nation is now entering upon a most intensive stage of its business history and national thought is being concentrated upon organization, conservation, and improved methods. There never was a more opportune time for the propagation of fire prevention and fire protection than at the present.

It is a recognized fact that whenever reforms are needed the people turn for advice to the experts in that particular pro-



HYDRAULIC LABORATORY

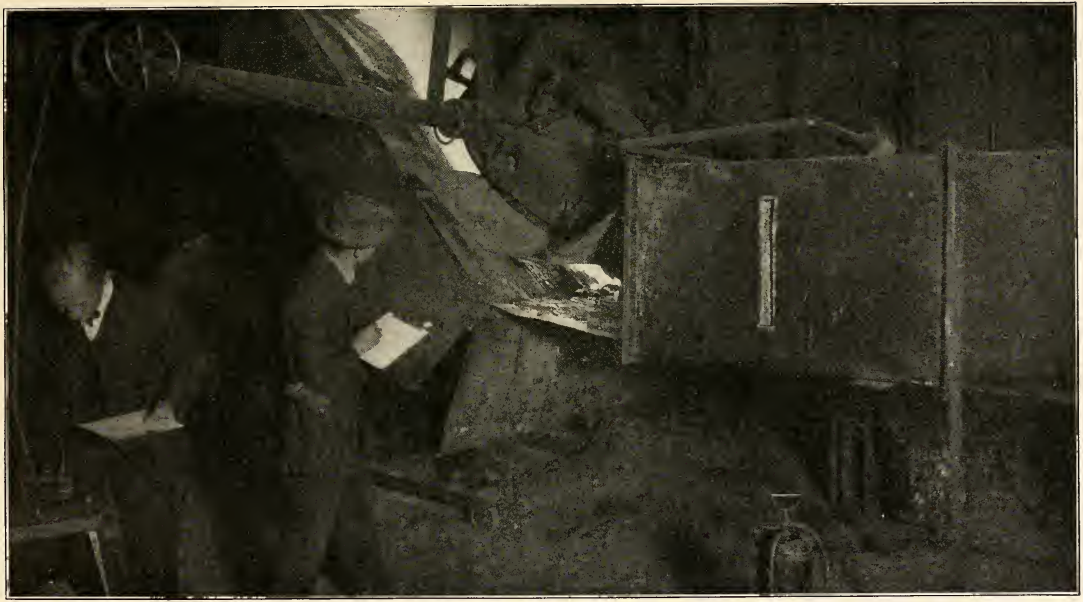
In this laboratory the students test dry pipe valves, alarm valves pumps, hydrants, hose, chemical extinguishers, and other devices of this general class. This laboratory is filled with appliances for delivering volume, creating pressure, or producing any desired test condition.

fession or business in which the reforms are desired. The medical profession and experts in sanitation are consulted when the public health is endangered and consideration is given to stamping out of contagious diseases. Leading bankers and financiers were sought by Congress for suggestions and advice in the formation of our Federal Reserve Banking System. In the same way, the people and the government itself are turning to the trained Fire Protection and Fire Prevention Engineer to curtail the enormous fire losses which this country has sustained.

The Profession of Fire Protection and Fire Prevention Engineering is yet comparatively new, but it is becoming more and more important due to its very nature, that of conserving the public welfare in relation to all matters affecting the hazards of life and property.

The growth of Fire Prevention engineering probably started back at the time when fire insurance underwriting was transacted under conditions which can best be described by the words of a man then vice-president of the Home Insurance Company: "this is a business of chances, therefore take all of the chances you can for the money you get." In those days the insurance inspector was not, as a rule, trained technically, made no effort to inspect a risk, as is now done, but had his own plan of guessing at the adequacy of the rate, the chief question being, "will the rate obtained cover the chance of Loss?"

The absurdity of carrying on the whole system of underwriting as simply one of the "magnificent guessing" resulted in the formation of the National Board of Fire Underwriters, of which more will be said later. The wonderful advancement in applied sciences and mechanical arts, which served to revolutionize old methods and bring into use new combinations in general manufacturing processes and methods created new and unknown fire hazards, and soon demanded inspectors possessing technical knowledge to enable them to keep pace with the changes in circumstances and conditions. Means were sought for eliminating or minimizing the probability of loss by exercising proper precautions for the prevention of fire, rather than to collect compensation in advance for unknown chances by the imposition



FIRE TEST OF ROOF COVERINGS

The students have the privilege of witnessing many interesting and instructing fire tests made on doors, windows, shutters, and other fire stops. In this picture, flame propelled by an artificial gale of forty-five miles per hour is subjecting the roof covering to a real conflagration test.

of a rate charge. Inspectors trained technically are able to not only discover hazardous conditions but also to suggest and apply proper and practical remedies for the correction of the defects under criticism.

Inventions constantly present new fire hazards. The rapid advancement in the electrical science; in the internal combustion engine, which made practical the automobile, motor-boat and aeroplane; in chemistry especially along the synthetic processes are continually introducing elements of the greatest danger. The giant new industry of moving pictures was not generally supposed to be hazardous until disastrous fires and serious loss of life resulted therefrom. In fact almost every new condition in scientific methods and processes present some new fire hazard and taxes the ingenuity of the fire prevention engineer to properly control and safeguard it. Mr. Willis O. Robb, manager of the New York Fire Insurance Exchange, once said, "It almost seems that whenever the chemists or electricians or the engineers or the mechanics of the country register a new advance in industrial efficiency a new corps of fire prevention experts have to follow after them to prevent their discoveries from burning us out of our national house and home.'"

The art of fire protection engineering has also grown apace with the other sciences. That such is the case, can best be shown by the rise of automatic sprinkler protection. Before the year 1875, little was done in the art of automatic control of fire. Factories and other buildings were protected from fire by perforated pipes placed overhead and into which water could be admitted by controlling valves placed in the risers where they could be easily reached. While there is mention of automatic sprinklers of various types back as far as 1723, none received more than passing mention. Along about 1875 the automatic sprinkler, patented by Henry S. Parmelee, seems to be the first which was put to any practical test. Since that time scores of other sprinklers have appeared until now it is one of the most efficient fire fighters of present times. Along with sprinklers came the development of alarm and dry pipe valves, pumps, tanks, and proper water supplies and now days the value of automatic sprinkler protection in contrast with unprotected property is almost universally recognized to such an extent that the entire cost of the installation can be saved, through reduced rate of insurance, in a few years. Going through our cities to-day one finds block after block in which every building is equipped with automatic sprinklers.

Obviously, Fire Prevention and Fire Protection Engineering are closely allied with Fire Insurance. The origin of fire insurance as a business may be traced to the Great Fire of London; it began in 1667 and was a response to the needs of the London sufferers. The first joint-stock insurance organization, the Friendly Society, was founded in 1864. Fire underwriting soon reached America, the first record being dated 1728. In 1752, the Philadelphia Contributorship was organized for the insurance of houses against loss by fire. From this time on the growth of American underwriting has been amazing and to-day there are few forms of activity that can be compared with it in size.

The vast business of fire insurance, with its thirty million policies and its $60,000,000,000 of protective contracts in the United States, is easily entitled to rank as one of the most fundamental factors in modern business life. Important business to-day is conducted almost entirely by means of credit, and insurance is the foundation of the modern credit system. As a matter of fact it would be impossible to carry on business without insurance against loss by fire. Credits would be almost impossible and trade would be practically reduced to a cash basis and the volume of business limited most disastrously. Fire insurance does away with the necessity for keeping capital idle, for without it careful business men would be compelled to maintain large reserves in cash or in convertible securities to guard against fire.

Another important value of fire insurance is found in the minimizing of business interruption for it makes possible immediate plans for resumption and reconstruction after a fire, thus giving a continuity to business that is exceedingly valuable. The most spectacular relation of fire insurance to modern business lies in the fact that it reduces to the lowest terms the paralyzing effect of conflagrations and distributes the burden of the loss throughout the country.

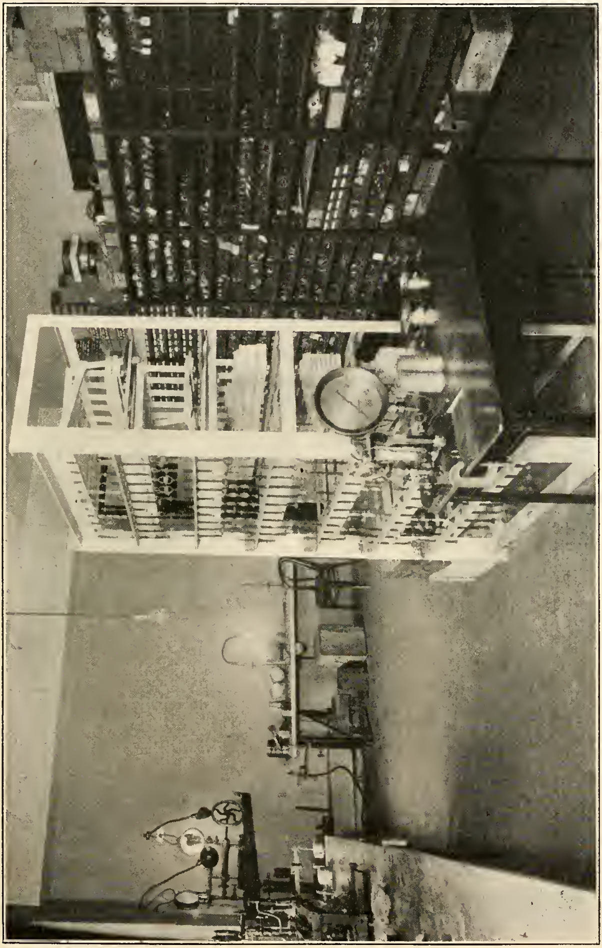
That the theory and practice of fire prevention and fire protection are recognized as one of the branches of the art of engineering is indicated by the attention being given to it by technical schools. Lecture courses on fire protection are given at Yale, Harvard, University of Pennsylvania, Stevens Institute of Technology, and some other colleges. Evening lecture courses are given at Columbia and New York Universities and by various firt insurance clubs located in some of the larger cities. A broad and comprehensive course of study is offered by the Armour Institute of Technology, this course having been started in 1903 and extends over four years. The laboratry work of this course is carried on at the Underwriters Laboratories, the remarkable testing plant maintained by the National Board of Fire Underwriters. Here with the cordial co-operation of the management, students are allowed to use the testing facilities, witness fire tests, and the like.

For the purpose of interesting young men in the profession of Fire Protection Engineering, and to aid in meeting the growing demand in combating the large annual fire waste, the Fire Underwriter's Association of the Northwest has established scholarships at the Armour Institute of Technology to be offered to students in the department of Fire Protection Engineering. These scholarships, one of which is offered each year, are four years in length and are of $700.00 value and are intended primarily for sons of citizens of the Western and Northwestern states.

Let us now conclude our article by looking into the opportunities in the field for the young man who makes a study of this branch of engineering. As the field of operation of the Fire Prevention and Fire Protection Engineer has become expanded and its value in the progress of business has become more highly appreciated, its operations, like those of other branches of engineering, are being segregated into specialties.

In the fire insurance field the opportunities which present themselves are apparently unlimited. The technical branches of fire insurance are rating, inspection, underwriting, adjusting, and brokerage.

In former years, each fire insurance company determined its



SPRINKLER LABORATORY

Students test under actual service conditions various types of sprinklers, carefully studying and determining their design, discharge, and distribution.

own rates, but, as the business and the competition grew, the need for broader data and collective experience led to the organization of rating bureaus. In the United States to-day there are forty-one rating bureaus covering as many different geographical areas. Ten are city bureaus and the others operate in portions of a state, in groups of states, or sometimes in a single state exclusive of its largest city. The rating bureaus determine rates for their component companies and also act as bureaus of information where specific data may be obtained regarding the effects on rates of all matters pertaining to the construction, occupancy, and protection of buildings and contents. In addition to making inspections of property to determine new ratings, the rating bureau, through their inspection departments, make more or less frequent inspections of all property within their jurisdiction for the purpose of noting defects or changes of occupancy which have any bearing on the hazards. Rating is one of the most important branches of fire insurance and being mathematical in scope offers a fascinating field to those who appreciate the possibilities of figures.

Inspection bureaus are formed and supported by the insurance companies doing business within a given territory. Similarly as the rating bureau performs a systematized and centralized service of rating so do the inspection bureaus in the matter of inspections. If no inspection bureaus existed, the individual companies would have to maintain their own corps of competent inspectors of risks underwritten by their agents. Inspection work is desired by many men in the insurance business because of its freedom from office routine, as its work is largely conducted outdoors.

The underwriting department of the insurance business offers some of the highest positions in fire insurance. The selection of the risks, which is in reality the foundation of the entire insurance transaction, require men who are able to use their knowledge, experience, and judgment.

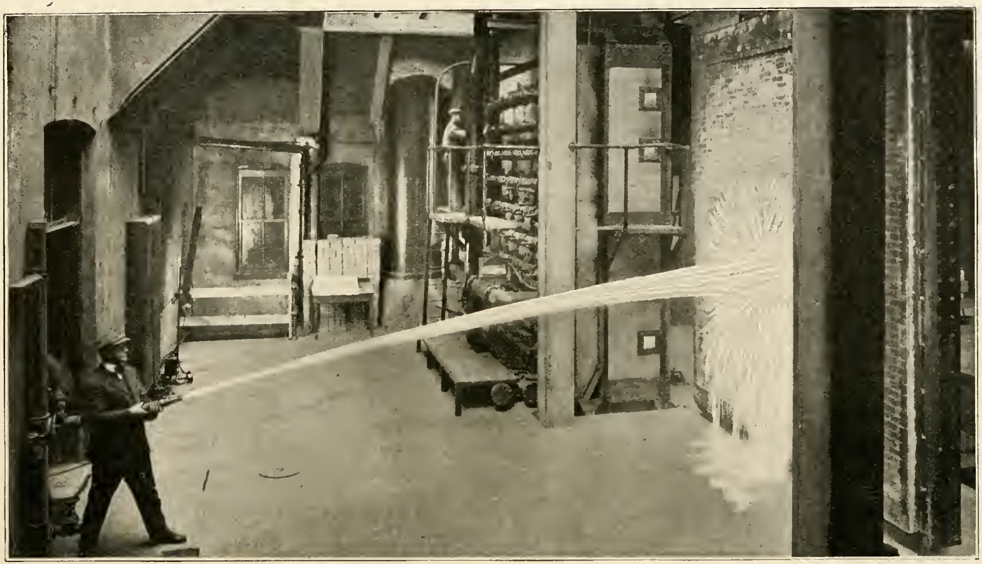
The adjustment of losses and the settlement of claims require men who have knowledge and experience along varied lines of work. Inasmuch as adjusting means the saving or the losing of definite and sometimes large sums of money by the company, competent adjusters are always in demand.

The brokerage branch of fire insurance is similar in many respects to the agency branch since a broker is primarily a business getter. The brokers principal technical functions are concerned with rating and adjusting. Since he is expected to purchase insurance for his clients at the lowest possible cost he must be a practical expert on rates, and in the actual settlement of claims he is also expected to act as his clients' adjuster.

Briefly listing them, the following are some of the many positions open to the engineer in the fire insurance field: Solicitor; local agent; special agent; broker, adjuster; examiner, heads of departments; general inspectors; special inspector as cereals, textile, electrical, and sprinkler; inspectorships with rating bureaus and inspection bureaus; insurance manager for firms carrying their own insurance; manager or general agent; and president of the company.

Should the young engineer be of a mechanical bent of mind he will find ample scope for the exercise of his faculties. The manufacture of fire prevention and fire protection appliances such as automatic sprinklers, automatic fire alarms, sprinkler alarms and supervisory systems, fire doors, windows and hardware, chemical extinguishers, standpide equipment, fire department apparatus, and the like offer a wealth of opportunity. New devices to prevent or afford protection against fire, which are constantly being designed, developed, and tested prior to being put on the market require the services of trained engineers. The proportion that these manufacturing industries of fire appliances have grown as evidenced by the General Fire Extinguisher Co., Kinnear Manufacturing Co., American La France Fire Engine Co., and hundreds of others show that the field is enormous.

The commercial end of the business offers many diversified and remunerative positions. The contracting and installing end of automatic sprinkler systems, private fire protective appliances, and auxiliary equipment and safeguards present innumerable opportunities. Companies manufacturing such devices as the one-quart and two and one-half gallon chemical extinguishers,



HOSE STREAM TEST

This picture shows a sample of building material being subjected to the impact of a standard hose stream after it has been burned for an hour in the panel testing furnace.

as well as those of the other sizes, the stationary chemical sprinkler systems, combined heating and sprinkler systems, fire doors and shutters, and many others require technically trained salesmen for their many branch offices.

With the rapidly growing fire problem and a growing realization of the responsibility of the states in dealing with the fire waste and its attendant loss of life, came the recognition of the need of a state department devoted to fire prevention and as a result the office of state fire marshall has been created in about thirty-seven states and Canadian provinces. In addition to state departments, many of the larger cities also have a bureau of fire prevention. The work of these departments have to do with the gathering and compiling of fire statistics, investigating fires of suspicious origin, inspecting buildings and other property, issuing of orders and recommendations for the improvement of fire hazards, and the education of the public of the state on the subject of fire prevention.

The large corporations, among them being Stone & Webster, Pennsylvania Railroad, Du Pont Powder, and the Victor Talking Machine Company have their own department of fire protection engineers. The Underwriters Laboratories, The Mutual Insurance Companies laboratry at Boston, The United States Bureau of Standards, and many of the private testing laboratories throughout the United States have openings for trained fire protection engineers to whom such work would appeal.

In short, the field for specialization in the profession of Fire Protection and Fire Prevention Engineering is no more restricted than it is in the other lines of engineering, and the young man who desires to take it up can find ample scope for the exercise of his faculties along the special lines which most strongly appeal to him. It is a profession charged with heavy responsibilities, for the life of every indoor worker may depend on the thoroughness with which the fire protection and fire prevention engineer has done his work.

NEWS FROM CAMP LOGAN.

Dear Friend:

I received your letter asking how I was getting along and I certainly was glad to hear from you. Also wish to say that I will be more than glad to write up a little article on my work, for it surely is interesting. I am always willing to take the opportunity of talking to old friends and fellow alumni thru the Engineer. This time my environments are a little different for I am in the service of the United States.

I am in a little 9 x 9 foot tent in one of the largest training camps of our new army, located at Camp Logan, Houston, Texas, assigned to Company E, 108th Engineers and have a company of 250 men. In this little tent I have my bunk, wardrobe, table, chair and stove; that is all resembling civilian life. The other articles I will enumerate for I believe they will be of interest. About 100 volumes of reading matter including "Kent's Hand Book," "Spooner's," "Gebhardt's," "Surveying Manuel," "Valve Gears," "French Grammar," "Musketry," "Bayonet Fighting," "The German Army Before the War," and etc., covering all phases of military training. Don't think for a minute that you do not find use for all of these books. I have had use for every one since I have been in the service and I certainly was pleased to have them with me. Yes, and the old slide rule has worked overtime on several occasions.

The other articles in my tent are my trunk; packed with complete war equipment of clothing, toilet articles (three years' supply) two pair of field shoes and six pairs of marching and dress shoes, a rifle and bayonet in one corner, a Colt automatic, web belt, first aid packet and canteen hanging on a side wall. On the other side hangs a hideous looking gas mask, the art of using which having been taught to us during the past two weeks. Then there are my dress arms, saber, belt, etc., and miscellaneous articles that are absolutely necessary.

My work is comparatively easy. Outside of getting up at 5.30 A. M., turning out the company, taking reports, conducting setting up exercises, handling details for various kinds of work (at one time I had six different details), caring for a few of the administration that fall to you, inspection at retreat of both men and rifles in the officers school, and then study, after which there is nothing else to do. Between 10:30 and 5:30 nobody cares what you do. You are kept busy but it is good for you and that is what we joined the army for.

Work of this nature is a pleasure and one enjoys doing it. I have been doing a little field fortification engineering. Here your slide rule and "trig" tables come in handy. That one detail however does not occupy all your time for there are others that need your attention.

You said that you would like an article on demolition, well here it is attached with a few pictures to lend a little action to it. I think they will be of interest to the boys. Hope this is what you want. If there is anything else just drop me a line.

Regards to all. Your friend,

(Signed) BILL BREADY.

DEMOLITION.

BY W. M. BREADY, JR.*

A large branch of the service is covered by the word demolition. Demolition has to do with the demolition or destroying of any and all objects that should happen to be necessary to eliminate. There are several means of demolition, namely:

(1) By fire.
(2) Improvised methods.
(3) Water.
(4) Wreckage.
(5) Explosives.

In the first, the burning of an object, such as a house, would be a means of demolition. In the second, an example would be the exploding of a boiler belonging to a power plant in order to destroy both boiler and power plant. In the third case, cutting away a dam or dyke to allow water destruction. In the fourth case an example would be to blockade and demolish the track in a tunnel causing a head on collision between two fast traveling locomotives. The fifth method, by the use of explosives, will do anything that the four preceding methods will do and the speed of setting and destruction is an immensely important factor. The surety of action is also a factor worthy of consideration. In fact railroads, locomotives and all rolling stock, and lines of communication in general can be destroyed, bridges blown up, roads destroyed, buildings and fortifications demolished by the use of explosives. This is the work that falls to the demolition section of the pioneer engineers. Later, a discussion of the application of "powder" which all explosives are nicknamed in the service, will be made.

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*Class of 1916

Explosives

There are a great many powerful explosives on the market and a number are used by the government. The following list will give an idea of the number in use of which a few are, or have been, used by the government:

(1) Triton.
(2) Picrates.
(3) Gunpowder.
(4) Nitroglycerine explosives.
    (a) Straight dynamite.
    (b) Low freezing dynamite.
    (c) Blasting gelatin.
    (d) Gelatin dynamite.
    (e) Ammonia dynamite.
(5) Ammonium nitrate explosives.
(6) Chlorate explosives.
(7) Rack-a-rock.
(8) Guncotton.
(9) Smokeless powder.

Of this list, gunpowder, smokeless powder, dynamite, rack-a-rock, trinitrotoluene (T N T or melinite) and guncotton are used. Rack-a-rock is not an issue, and guncotton is in naval use, thus the explosives now issued in the army are few.

Gunpowder, smokeless powder, dynamite and Triton are issued. The smokeless is used in rifle cartridges and artillery work exclusively and black powder is used for firing purposes.

Dynamite and trinitrotoluene are the explosives that are issued and used by the Engineers of the U. S. Army and, of course, are the explosives that will be spoken of in this article.

Triton (T N T or trinitrotoluene), is the regular service

Identical of a Large Shell Explosion.

"powder" and the reason can easily be seen from the subsequent description of the "dope."

Description of Explosives

Dynamite is a powerful explosive issued in strengths 35 and 40 per cent. It can be bought in the open market 20, 30, 35, 40, 50, 60, 70, 75, 80 and 85 per cent strength, but the higher the percentage, the more dangerous it is to handle. Forty per cent is the proper strength for safe transportation. The percentage refers to the equivalent strength of a saturated stick of nitroglycerine. Dynamite is simply a base material of Fullers earth, sawdust or wood pulp, saturated to a certain percentage with nitroglycerine. A few other ingredients, sodium nitrate, calcium and magnesium carbonate are used in small quantities. The material is packed in small cylindrical cartridges of parafined paper 1¼ inches diameter by 2 inches in length. (These cartridges are easily broken by circling with the thumb nail and breaking.)

Contact with the material itself or the fumes after an explosion produce a severe headache.

Dynamite requires careful handling, and must be turned over once every four days in order to prevent the nitro from collecting in a spot or globule, in which state it is dangerous to handle. It must never be worked on with steel, wood always being used. It should not be dropped or jarred or handled roughly in any way. Compare this with the description of triton. Contact with water causes a separation of the base and nitroglycerin, in which state the dynamite is dangerous to handle.

Triton, the authorized explosive of the service is a crystalene yellow salt of a density of about 1.5. It is produced in two forms, block and stick; the block being 1⅞" × 1⅞" × 3¼" and the stick 1¾" × 3". It is very solid and well compressed and has one objectionable quality only. It absorbs water very readily, spoiling the powder completely. To prevent this the block is paraffin coated and then copper plated. The hole for the detonating cap is bored in the stick and a paraffin cork inserted. Triton can be cut with a knife, dropped or ground under an axe or hammer; it burns very slowly with a heavy dense smoke and requires a very violent detonation to explode it. It is the ideal explosive for all purposes, being easily transported and is quick and sure.

Detonators

All explosives are "fired" by a detonating cap or fuse. To detonate a certain explosive it is necessary to produce a specific wave motion in the presence of heat in order to cause combustion. This is done by means of a cap or fuse of which there are two types. The first is the ordinary blasting cap, which is simply a copper shell with a definite amount of fulminate of mercury in it. A piece of fuse is inserted and the cap crimped and then a flame applied. The heat, upon contact with the fulminate, causes a detonation. The second type is the electric fuse, of the same construction as the other cap, except that the end is sealed with a sulphur block thru which passes the terminals of the conductors. Between these two conductors is a small piece of platinum wire, buried in the fulminate. An electric current, generated by the "push rod type" of magneto and transmitted thru a coil and line of wire known as the lead wire, causes heat and consequently a detonation.

Fuses

Three types of fuses are used in demolition work. They are known as Bickford, Instantaneous and Cordeaux.

Bickford is a white cord about 3/16-inch in diameter, smooth on the outside and has a rate of burning of 3 feet per minute. This is approximate, and for exact time work the fuse should be tested by burning a certain length.

Instantaneous is about ¼-inch in diameter and is bright red and rough, due to cross wrapping of heavy thread. This enables the user to distinguish between the slow fuse and the fast fuse at night. It has a rate of burning of 120 feet per second.

Cordeaux is a lead casing filled with powdered triton, about ⅛-inch in diameter. It truly is instantaneous in its action, traveling approximately 6000 feet per second.

The Bickford and Instantaneous fuses are lighted by flame, while the Cordeaux is detonated by a cap.

Loading

In loading a cartridge of either triton or dynamite, the cap is inserted into a hole (bored by a wooden stick in dynamite) or in the stick or block of triton. It is at this point that explosives become dangerous. In handling explosives the great danger lies in the fulminate caps and not in the "powder." A half hitch of the wire is thrown over one end and then doubled back and tied to the other end. This is a precaution to prevent accidental discharge by jerking the wire. One primed stick, as it is called after loading, is sufficient to detonate all powder in the hole.

Use of Explosives

A bridge can easily be destroyed by this means. Let us take for instance a steel railway bridge of two spans. The upper and lower chord on each side are cut by the proper placing of the charge, thus removing a complete section. At the same time a charge is placed under the center pier and under the abutments. The amount of explosives necessary can be figured as follows:—

$N = \frac{3}{4} A$

where $N =$ number of sticks of T. N. T.

$A =$ area of steel members (actual steel cross section).)

The laying of the charge is a matter different for each individual job. The tamping is done with mud.

The charges for the pier and the abutments are figured by the following formula:—

$$N = \frac{5}{4} R^3 K C$$

where $N =$ number of sticks of T. N. T.

$R =$ radius of rupture (distance from the charge to extremity of wall.)

$K =$ constant for particular material.

$C =$ Constant for tamping and location of charge.

For masonry $K = 3$ and for reinforced concrete $K = 2$. $C = 1$ for excellent location and tamping, for instance in a drill hole in which the charge was well packed. C would equal 3 for a charge which was required to be laid along side of the member to be cut.

These charges are set off simultaneously, causing a section to be removed and dropped into a stream bed, also destroying the approach.

A railroad track can be destroyed by several methods. Several charges placed under the ties, directly below the rails, destroy the ties and rod beds. Two sticks of triton placed on opposite sides, alternate of each other will cut a rail in any required place. Two sticks of 30 per cent dynamite on opposite sides alternate of each other, about 12 feet apart, will twist and bend the rail beyond repair.

A culvert under a roadbed can be mined or blown up directly, demolishing the roadbed.

A rather interesting use of explosives is in the cutting of trees. It is possible to cut trees off and drop them along side of the stump; blow them out entirely, roots and all; or cut them off above the stump and throw them any distance within reason in any direction, providing the lean of the tree is not too great.

Destruction of an Observing Point—A 125 ft. Brick Chimney.

The methods employed in cutting timber are very interesting. A "V" notch cut into one side and a bored hole on the other, loaded with powder, will make a clean cut. Three holes bored into the tree, one shallow and two deep, 100 degrees apart, will cut and pitch the tree in the direction of the shallow hole. A chain of sticks tied around a tree or timber will cut it off, and by doubling up on one side, the tree can be pitched to the opposite angle.

Roads are destroyed by the detonation of mine chambers under the road, or are blocked by causing landslides onto them.

The destruction of the chimney in the accompanying picture presents a fair problem in this work. It was supposed to be a valuable lookout for the advancing enemy. Orders were to destroy it immediately with all possible speed. Time could not be taken for calculation, it was one of those cases where experience was the guide. Ten sticks of triton in one corner, twelve in another, and twelve placed in a row along the opposite wall to the two corners, a hurried electrical connection and a terrific explosion, the results of which you can see. A time interval of about eight minutes was all that was required. The violent eruption in the other photograph is the explosion of 146 sticks of T. N. T. This produced a crater 28 feet across and ruptured the dirt to a depth of 13 feet.

Remains of the Chimney—Arrow Shows Col H. H. Allen, 108th Engineers; and to His Left, Lieut. Bready.

Steel plate, I-beams, Z-bars, rails, etc., can easily and fairly accurately be cut by quick acting triton.

The use of explosives is interesting and can never be learned to a stage where all is known, because at that stage one becomes careless. There are rules governing the use of explosives that make all men respect them highly and handle them carefully. These rules should be observed, and the demonstrations presented should make a man think of what he is doing while employed at this work. One thing that men who handle explosives know is that they can make only one mistake.

A DYNAMOMETER CAR

RALPH H. EARLE*

With Cutler-Hammer Mfg. Co., Thomas Mete Department.

FOREWORD—For permission to write the following article, as well as for much of the material presented, the writer is indebted to Mr. H. B. MacFarland, Engineer of Tests of the Atchison, Topeka and Santa Fe Railway System.

Introduction

A dynamometer car is a piece of railway equipment used primarily in the making of road tests on locomotives. By road tests is meant those tests of a locomotive (considered as a steam power-plant) made during the actual train-service of the machine as distinguished from those tests made in the laboratory. Such work requires heavy apparatus, and also necessitates irregular hours of duty upon the part of the crew; hence it has been found desirable to assign a special car to test work exclusively and to equip this car with the necessary apparatus, together with living quarters for the crew. Such a car is coupled into a train hauled by the locomotive under test, and the data is accumulated throughout the run of the engine.

It is the purpose of this article to explain some of the general requirements of dynamometer-car work, with the apparatus developed to fill these needs, particularly as exemplified by the car of the Atchison, Topeka and Santa Fe Railway System. Only the general schemes of the equipment are discussed, as no attempt can be made to give details of design in this short discussion.

General Notes on Locomotive Tests

Before a description of a dynamometer car and its equipment is begun, a few characteristics of locomotive test data should be outlined, which characteristics become apparent through a consideration of the load conditions of locomotive service as compared with the more familiar conditions found in the operation of stationary plants. The fundamental difference in these two cases is that whereas the load of the stationary plant is reasonably constant, or changes but slowly, the load of a locomotive fluctuates almost continuously over a wide range. Some of the factors which affect the locomotive in this respect and are likely to vary are the length, weight and character of the train; the nature of the track as to grades, curves, condition of the roadbed and dryness of the rail; the temperature, wind and weather conditions; the speed of operation and, occasionally, the frequency of stops; and many other factors, few of which are present in stationary practice.

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*Class of 1917

These variable factors have a distinct bearing upon locomotive-test data as compared with the test data of stationary plants.

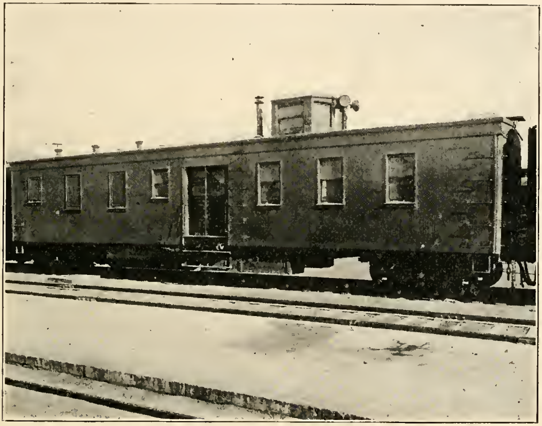


Fig. 1.—Santa Fe Dynamometer Car.

In the latter case, series of periodic readings or logs are usually taken throughout the interval of the test; these determinations embrace such factors as size of load, R. P. M., indicator cards, steam pressures, coal fired, and the many other quantities familiar to the reader. In locomotive testing, however, series of periodic readings of many of these quantities have been found insufficient because of their continuous variation; this fact is particularly true in the cases of load and speed. In such cases, it has been found desirable to obtain continuous records, principally in the form of curves or graphs, which show the magnitude of the factors at every instant throughout the test period.

These varying quantities depend in a great measure upon the varying conditions of operation, as was just explained, and as a result it is desirable that the operating conditions be noted along with the performance records in order that these records may be properly interpreted. Besides these continuous records, many complete logs are kept, similar to those taken in stationary tests.

The continuous records of locomotive performance and the accompanying operating conditions, being in the form of curves or other graphs, are kept on a continuous paper chart, an example of which may be seen in Fig. 2. Briefly, the chart is a long strip of paper which, throughout the test, travels in a direction along its length under a row of curve-drawing pens, this row extending cross-ways of the chart. Each of the pens leaves a trace extending along the length of the completed chart, and each trace forms a conventional record of one of the factors under observation. For example, in Fig. 2 trace No. 10 registers draw-bar pull; trace No. 7, speed; No. 2 shows the location of the train; and so on through the list of measurements. Furthermore, since the pens lie in a straight line or row extending across the chart, simultaneous records of the various factors are recorded along this line, so that any line drawn across the completed chart perpendicular to its length cuts the several traces at points which were registered at the same instant. By this means, all the conditions of locomotive performance can be determined for any point in the test. Explanatory notes are placed on the chart wherever necessary.

The advancement of the chart under the row of pens is accomplished by a machine geared to the car axle so that chart-travel, or length of the completed chart, is proportional to the revolutions of the car axle or to the distance traveled by the train. During periods of train-stop, the chart-paper is driven by an electric motor so that the lengths of chart produced during stop-periods are proportional to the lengths of those periods.

The result is that the completed chart forms a sort of picture of the test; the distances along the length of the chart correspond accurately to the distance traveled by the train and to the duration of the stops, whereas the graphs and notes record the inci-

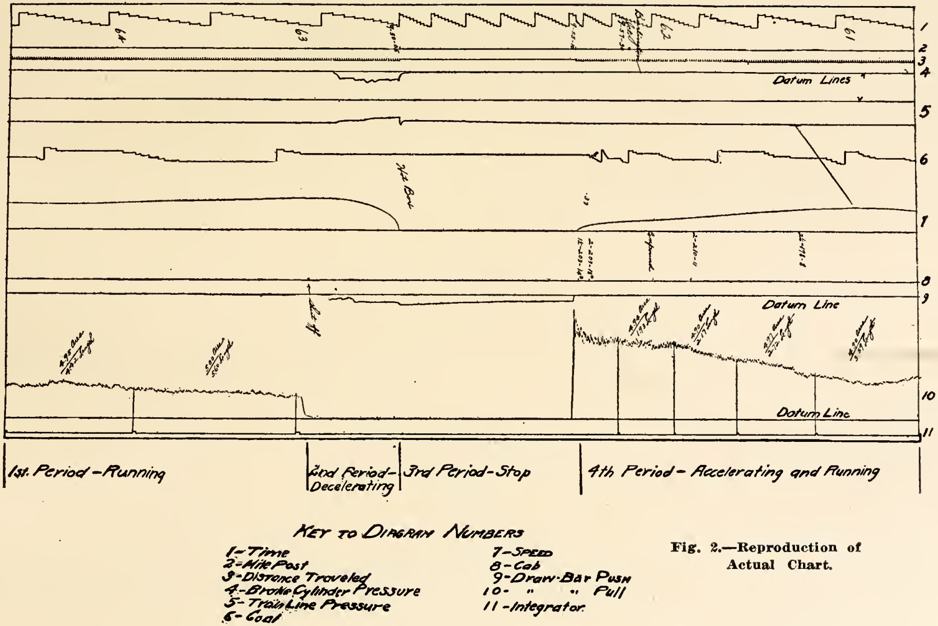


Fig. 2.—Reproduction of Actual Chart.

dents of the test in their order of occurrance. This chart, together with the several logs kept of the run, constitutes the locomotive-test data.

In addition to these general ideas of test data as just presented, it will at this point be well to outline the procedure followed in the making of a test. Before the test run begins, the dynamometer car is attached to the front of the train of cars with which the run is to be made, so that in the completed train, the dynamometer car will be located directly behind the locomotive. A few minutes before the locomotive appears, the chronograph, as the chart-drawing machine is called, is started and the chart is begun. At the instant the locomotive couples onto the front of the car, the test proper begins.

When the locomotive has coupled onto the train, the various observers in the test-crew take their stations. The location and number of observers depend upon the nature of the test in progress. There is, of course, an operator at the chronograph; an observer is stationed in the observation cupalo on the top of the car and a second in the cab of the locomotive. In case indicator cards, draft pressures and strain temperatures are to be taken, additional men are located upon the pilot and running-board of the engine. Communication is maintained between the observers and the chronograph by portable telephones and by electric push-button systems, the push-buttons being located at the observers' stations and controlling functions of the chronograph, as will be explained later.

At the instant of starting of the train, the routine work of recording data begins and continues throughout the run. The dynamometer car is not uncoupled from the locomotive at any time during the test; whenever it is necessary for the locomotive to leave the train, the cut is made behind the dynamometer car so that the car remains with the engine.

As for the duration of the test, each run usually corresponds to the run of the engine, that is, one hundred miles in freight and two hundred miles in passenger service.

With these ideas of a dynamometer car and its operation in mind, we can now consider in more detail the test data obtained and the means for taking it.

Locomotive Test Data

The data, consisting of the chart and logs, may be divided into two classes: the primary data, which comprises a record of locomotive performance, and the supplementary data, showing the operating conditions under which the performance record is made. The first or primary class includes the fundamental measurements of draw-bar pull, draw-bar push, and speed, together with airbrake performance, coal fired, water used, indicator cards, steam temperatures, draft measurements, throttle opening and reverse-lever position; in addition to these determinations, others may be made as the nature of the test demands. The supplementary records comprise location of the train or distance traveled, weather conditions and make-up of the train. There are also records of time, starts and stops of the train, stations passed, and any other features of value in the interpretation of the data.

Now consider this data as recorded on the section of chart shown in Fig. 2. The section here presented gives record of the operation of a freight train over an interval of about sixteen minutes, during which time the train is initially running at full speed, later is forced to stop because of a hot-box, and, after an interval of about five minutes, resumes its travel. This example of chart not only illustrates the methods of registering data, but also shows how the length of the chart representing running periods corresponds to the distance traveled by the train, whereas the length of the chart during periods of train-stop varies directly as the duration of that stop.

Taking up the individual records, we find that of draw-bar pull designated as No. 10 in Fig. 2. This record consists of two lines: the curve of draw-bar pull and a datum line. The datum line is straight and is drawn along the zero axis of the curve, so that the line marks the position assumed by the curve when the draw-bar pull is zero. When a pull occurs at the draw-bar, the curve rises from the datum line in such a manner that the distance between the two lines is always proportional to and hence a measure of the force at the draw-bar.

For example, during the stop period, shown in Fig. 2, the draw-bar pull curve lies along its datum line, for during this time, there is no pull at the draw-bar; during the running periods, however, the curve rises from its datum line, the distance between the two lines at any instant being a measure of the draw-bar pull.

In a like manner, the draw-bar push or buff curve (No. 9), together with its datum line, indicates the push of the locomotive against the train. Such a condition of push occurs principally during backing and decelerating movements of the train, so that in general, the buff curve lies along its datum line.

A further consideration of the two draw-bar curves shows that the area under each curve measures the work performed by the locomotive upon the train during the interval under observation. This fact exists since the height of either curve above its datum line is proportional to the draw-bar pull or push, and the length of the curve along the datum line equals the chart-travel, proportional to the distance traveled by the train; hence, the area under the curve, being the product of force times distance, is a measure of the work expended by the locomotive upon the train.

For the more convenient measurement of this area, a planimeter or integrator diagram has been added to the draw-bar records on the Santa Fe test car, and, although not an essential feature of the data, this diagram warrants a brief discussion of this point. The integrator is marked No. 11 in Fig. 2, and consists of a straight line extending along the length of the chart, parallel to the datum line, and broken at intervals by small offsets. The occurrance of each offset marks the enclosing of five square inches of chart-area under the draw-bar pull curve. That is, if ordinates be erected from the datum line to the curve at points marked by offsets, the area of the figure bounded by two successive ordinates, the curve and the datum line is five square inches. This area divided by the length of the base of the figure shows the average draw-bar pull over the interval. These calculations are illustrated on the section of chart shown in Fig. 2.

The method by which the diagram is made is briefly as follows: The pen which draws the integrator diagram is connected by levers to the armature of an electro-magnet. This magnet is normally de-energized, and under such conditions, the pen draws the straight line portions of the diagram. When the magnet is energized, the pen is displaced slightly, and this displacement, together with the subsequent return of the pen to its original position, forms an offset in the diagram. The control contact of the electro-magnet, by the closing of which the magnet is energized, is operated by the integrator. The integrator consists of a planimeter of the disk and crown-wheel type, the details of which need not be discussed at length in this article. The device is governed by the draw-bar pull and the distance traveled by the train, as measured by the revolutions of the car wheels, and is so arranged as to close the control contact and consequently form an offset in the integrator diagram at each five square inches of area under the pull curve.

The next chart record to be considered is that showing the speed of the train. This diagram consists of a curve, together with a datum line, as shown in Fig. 2, Diagram No. 7. The datum line marks the zero axis of speed, that is, the position of the speed curve when the train is stationary. During intervals of the motion of the train, the curve is displaced from the datum line, and the amount of this displacement is a measure of the speed.

An illustration of this action is furnished by the speed curve of Fig. 2, for here the speed curve lies along its datum line during the time of stop, but, as the train starts from rest and gradually attains full speed, the speed curve rises from the datum line. The length of the ordinate to any point of the curve is directly proportionate to the speed of the train at that instant.

The net available power exerted by the locomotive upon the train at any instant may be calculated from the magnitude of the speed, or, more properly, the velocity of the train at any point and the corresponding value of draw-bar pull. Also, the kinetic energy of the train can be calculated for any desired point of the run from the value of speed, as shown by the speed curve, and the weight of the train. This calculation is particularly useful at the beginning of a braking period, as it then shows the energy dissipated in the brakes.

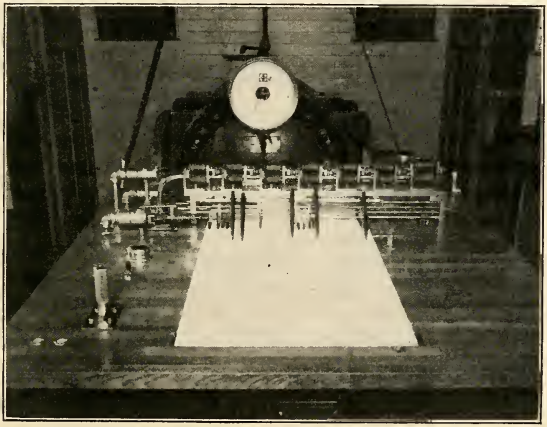
The air brake performance, which is the next feature of train operation to be studied, is recorded by diagrams No. 4 and 5 on the chart of Fig. 2. Diagram No. 5 shows the pressure of the air in the train-line of the brake system throughout the test, whereas diagram No. 4 shows the pressure of the air in the brake cylinder of the dynamometer car, this latter pressure being assumed to be the same in all brake cylinders of the train. The schemes of these two diagrams are similar. Each consists of a datum line and a curve of air pressure. The datum line marks the axis of zero pressure, and the distance by which the curve rises above, or in No. 4, falls below the datum line, is proportional to the pressure being measured. Hence, the positions of these curves with respect to their axes throughout the run gives a continuous record of air pressures in the brake system.

As will be seen in the figure, the train-line pressure is constant (at about eighty pounds per square inch) except during brake application, when the pressure reduces slightly. Hence the pressure curve is in general a straight line parallel to the datum line. The pressure in the brake cylinder, on the other hand, is zero except during brake applications, when the pressure builds up from zero. Hence in general the curve of brake-cylinder pressure lies along its datum line. These two curves, therefore, give record of air-brake performance, particularly as regards the time, duration and pressure-characteristics of the applications.

The next consideration in our treatment will be the record of coal fired, as shown by diagram No. 6 on the chart. This diagram consists of sections of straight lines extending along the length of the chart but broken at intervals by "stair-steps," called multiple offsets. Each offset or step marks on the chart the point at which a scoop of coal is fired in the engine.

The method of producing this record is as follows: The cab observer has at his disposal an electric push-button which he depresses momentarily at the firing of each scoop of coal. This push-button controls an offset movement in the chronograph in such a way that when the button is depressed, the pen making the coal diagram is displaced slightly to the right. The chart is traveling slowly all the time, so that this displacement of the pen, together with the chart movement, produces a step in the coal diagram. In this manner, the steps or offsets are introduced into the diagram, the cross-line of each step accurately marking the instant of firing of a scoop of coal.

An additional feature of the coal diagram is the arrangement of the steps or offsets in groups of ten. The recording mechanism on the chronograph is so constructed as to make the first nine steps of a group additive, that is, at the reception of each successive signal from the cab, the pen is moved one step farther toward the right on the chart. At the tenth signal however, the mechanism returns the pen to its initial or extreme-left position. The diagram, therefore, indicates nine offsets or steps toward the right, and then one large return-step to the left, so that the steps are marked off in groups of ten by the large return-steps. This feature of the diagram is convenient when the total scoops of coal fired over a given section of chart are to be determined, for the scoops or offsets can be counted by tens instead of by individual steps. In addition, the push-button of the cab observer may be equipped with a mechanical register or counter, the reading of which at any instant shows the total scoops of coal fired. These readings may be noted on the chart at frequent intervals.



Besides watching the coal as fired, the cab observer determines the total weight of coal fired during the test. He determines this amount by noting the total weight of coal loaded onto the tender and the amount remaining at the end of the run. The difference between the two amounts of course equals the weight of coal fired. In the calculation of results, this total weight of coal is distributed equally among the total scoops fired, so that each scoop is assumed to equal the average. Although this may appear to be a rough method of calculation, experience has shown that the actual weights of the individual scoops of coal tally very well with the average weight assumed.

In addition to the coal record, the cab observer keeps a log of water used during the test. This log records the depth of water in the tank of the locomotive tender at frequent intervals throughout the test, from which readings may be determined the amount of water utilized.

Next in the order of treatment occur such records as steam pressure, throttle opening and position of the reverse lever of the locomotive, all of which factors are under the observation of the cab man and are recorded on diagram No. 8.

This cab diagram, No. 8, is seen to consist of a straight line, extending along the length of the chart, with short cross-lines cutting the line at intervals. Each of these cross-lines may be termed a "momentary offset," to distinguish it from multiple offset, or similar "offset," and marks the instant at which observations were taken in the cab of the locomotive.

The means by which this record is made is somewhat similar to that employed with the coal record. A second push-button circuit is run from the chronograph to the observer's station in the cab, and a push-button located at the latter point. The circuit is so arranged that when the button is depressed, an electro-magnet on the chronograph is energized, and this magnet, through a system of levers, draws the pen making the cab diagram a short distance sideways. Upon the release of the button, the magnet is de-energized and the pen returns to its initial position under the action of a spring. As a result of this pen movement, a temporary offset occurs in the usual straight-line trace made by the pen. The displacement of the pen continues for only a moment, that is, during the momentary depression of the push-button; during this time the chart movement is negligible, so that the offsets become merely short cross-lines cutting the main trace instead of being drawn out into steps.

The push-button is depressed at each instant observations are taken in the cab, these observations being subsequently telephoned by the cab man to the chronograph operator, who notes them on the chart beside the offset. The observations are taken for every change in throttle opening, reverse-lever position, for every material change in boiler pdessure, and for any other functions which it desired to record.

The observations are recorded on the chart by a somewhat conventional notation, as is shown in Fig. 2. Each notation consists of three sets of numbers, such as 1½—203—14S, this being the first notation on the cab diagram after the end of the stop period. The first number, 1½, shows the throttle opening in quarter-inches measured on the throttle stem; the second number, 203, is the boiler pressure in pounds per square inch, as shown by the steam gauge in the cab; the third number, 14, denotes the number of notches off-center of the reverse lever, these notches referring to the teeth in the reverse-lever quadrant. The letter "S" is to indicate that the engine is running under conditions of simple expansion; a subsequent record marks the point at which these conditions were changed to compound expansion.

The last of the performance records to be taken up are those involving indicator cards, and readings taken from the running-board of the locomotive, such as steam temperatures. These records are not kept on the chart directly, but instead, the actual readings are kept in the form of logs by the observers stationed on the pilot and running-board of the locomotive; only the points in the run at which readings are taken are registered on the chart. The successive readings as they appear in the logs of the observers then correspond to the respective locations at which readings were taken as these locations occur on the chart.

Chart records of these determinations do not appear on the section of chart shown in Fig. 2. The diagrams are similar in form, however, to the cab diagram; that is, each consists of a straight line extending along the length of the chart, with short cross-lines or momentary offsets occurring at points where readings were taken by the observers. As in the case of the cab diagram, the offsets are produced by the depression of push-buttons at the points or stations of observation. Three such diagrams are provided, one for indicator cards taken on the left-hald side of the engine, one for cards taken on the right-hand side, and one for observations made from the running board.

The indicator and running-board diagrams, with their logs, constitute the last of the primary records, which, it will be remembered, are those of locomotive performance; the next considerations in order of treatment are the supplementary records whose purpose is to show the external conditions, such as condition of the track, under which the test is made.

The first of these supplementary records to be taken up are those which show the location of the train at any instant in the run. Two diagrams are used in this connection; one, No. 2 in the figure, registers the passing of mileposts, thereby accurately locating the train at every mile; the second, No. 3 in the figure, shows the distance traveled by registering the revolutions of the car wheels, and thus shows the location of the train within a few feet during the intervals between mile-posts.

The mile-post diagram, as shown, is of the same form as the cab and indication diagrams, that is, it consists of a straight line extending along the length of the chart and having momentary offsets or cross-lines at intervals. Each offset marks the passing of a mileposts by the car, or else marks one of the occurrances to be mentioned presently; the number of the milepost or any other explanatory notes are placed on the chart beside the proper offsets. The offsets are produced by the depression of an electric push-button located in the car, the scheme being identical with the one followed in the cab and indicator records. The button is depressed at the instant of passing a milepost or at the instant of the occurrance to be noted, and the resulting offset on the chart accurately registers that instant.

Besides the passing of mileposts, these offsets are used to register the passing of stations, the instant of starting and of stopping of the train, and a variety of other incidents.

The second or distance-traveled diagram, shown as No. 3 in the figure, consists of a straight line extending along the chart, together with short cross-lines or momentary offsets which occur at short regular intervals. The distance between two successive offsets corresponds to a certain number of revolutions of the carwheels, which distance, for instance, may equal thirty feet of car-travel. The recording device is somewhat similar to the mile post, cab, and indicator recorders already described. The pen in its normal position draws the straight longitudinal line, but is displaced by the energizing of an electromagnet, the displacement and subsequent return of the pen to its original position forming an offset of the completed diagram. The control contact of this magnet consists of a brush and a commutator geared to one of the axles of the car. The contact is closed and an offset produced in the diagram at each revolution of the commutation, and as the revolutions of the commutator are directly proportional to the revolutions of the car wheels, the offsets are a record of the distance traveled by the train.

The great utility of these records showing the location of the train is that the track conditions for any point on the chart may be ascertained by means of these chart diagrams and plans, profiles and notes of the track passed over.

Besides a record of train location, a continuous record of time is provided, this record being diagram No. 1 on the chart of Fig. 2. As is shown, the diagram consists of a continuous series of steps or multiple offsets, arranged in groups of ten; the individual steps are similar to those of the coal diagram, No. 6. In the grouping of these steps, the first nine offsets of a group are made additive, that is, there is a continuous advancement of the diagram from left to right on the chart; at the tenth step, however, the line returns to its initial or extreme left position, at which point the next group of steps begins.

Each of the large steps or groups of ten represents the interval of one minute, whereas the individual offsets show intervals of one-tenth minute or six seconds. The diagram is made by a pen which is offset every six seconds by an electro-magnet; the magnet is energized through the periodic closing and opening of a contact operated by a clock.

It will be noted that this diagram does not show the actual hour of the day, but serves only to measure intervals of time. The actual time of day in hours, minutes and seconds is frequently noted on the chart by the chronograph operator. By means of these notations, together with the diagram, the actual hour of the day may be determined for any point of the chart.

The diagram of time concludes the list of chart records which are most essential in locomotive work. There are many other less important occurrances during a test to be observed, but it is hardly possible to consider them in this brief discussion.

The Interpretation of the Chart

Having gained a knowledge of the records appearing on a completed chart, let us now briefly analyze the section of chart shown in Fig. 2 in order that we may understand the interpretation of such records. As was previously explained, the section presented extends over an interval of about sixteen minutes of time operation, during which time the train is initially traveling at normal speed; a hot-box developed on one of the cars and necessitates a stop. A stop of about five minutes is consequently made, and at the end of this time travel is resumed.

For the purpose of analysis, the interval of train operation shown on the chart may be divided into four periods: first, the initial period, during which the train is traveling at normal speed; second, the decelerating period; third, the time or duration of the stop; and fourth, the period of acceleration together with the remainder of the chart-interval, during which latter time, the train is again traveling at normal speed.

During the first or running period, the routine conditions prevail. The draw-bar pull curve is displaced from its datum line by an amount which we will assume denotes an average of 20,000 pounds pull on the draw-bar, and the speed curve, by the length of its ordinate, shows the average speed to be perhaps 18 miles per hour. The locomotive is then developing about 1000 horse power, and, if it is drawing a 2000-ton train, the kinetic energy of the train is about 50,000,000 foot-pounds. An interesting feature of the two curves is that a rise in the speed curve is accompanied by a depression of the draw-bar pull curve, and vice versa, this occurrance showing that the draw-bar pull is greater at low speeds than at high, and consequently that the power developed by the locomotive tends to be constant. The brake pressure curves show that the train line pressure is constant, the curve being parallel to the base line, and the brake cylinder pressure is zero, as might be expected under running conditions of the train. The coal diagram indicates that coal is fired very frequently. The location of the train is registered continuously by the distance-traveled diagram and the mile-post diagram; the latter indicates that mile-post 64 is passed at about the middle of this first interval. It is interesting to observe that the length along the chart of the steps in the time diagram varies directly as the speed of the train; at high speeds, the distance traveled and hence the chart-travel per minute is greater than at low speeds, and the steps in the diagram are consequently longer. In this way, the length of the steps of the time diagram is a measure of the train speed.

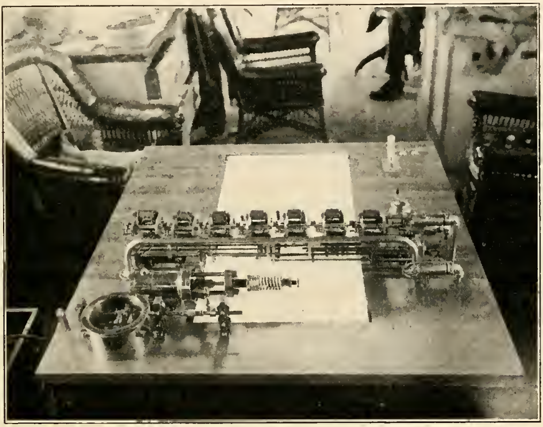
Events continue in this fashion until there occurs an offset marked "Shut off" on the cab diagram (No. 8), which incident marks the beginning of the second or decelerating period. This offset is the first indication on the chart that a stop is to be made, and shows that at this instant, the throttle of the locomotive is closed. The draw-bar pull curve drops at the closing of the throttle, thus showing an abundant reduction in pull; there is, however, not a great change in the speed of the train as shown by the speed curve at this instant. Just after the closing of the throttle, there occurs an application of the brakes, which event materially reduces the speed. This brake application is indicated by a reduction in the train-line pressure, as shown by curve No. 4, and by the consequent building-up of pressure in the brake cylinder; the pressure curves accumulately show both the duration and pressure-characteristics of the application. As the brakes are applied, the draw-bar buff curve, No. 9, indicates a backward push of the locomotive against the train, and this push continues throughout the period of deceleration. As the train thus gradually comes to rest, the deceleration period ends.

The end of the decelerating and the beginning of the third or stop period is marked by an offset in the mile-post diagram (No. 1). The time of stopping, 9:50:05, is noted beside the offset; at this same instant, the chart drive is shifted from the car truck to the electric motor.

The character of the chart diagram during periods of train stop are well illustrated by that period in Fig. 2. The curves of draw-bar pull, speed and brake cylinder pressure have dropped to their datum lines since their respective governing functions are now zero in value. The curve of train-line pressure, No. 4, has reassumed its constant value, thus indicating that normal pressure was required after the brake application was completed. The distance-traveled diagram, No. 3, appears as a straight line without offsets, thus showing that the train is at rest. The steps in the time diagram are regular and uniform in length, which form illustrates the constant rate of chart-travel under conditions of motor drive. In this manner, the records continue throughout the interval of stop.

The fourth period begins at the instant the starting of the train as recorded by an offset in the mile-post diagram, No. 2, together with a notation showing the time of start, 9:55:10. At this instant, the source of chart-drive is changed from the motor back to the car truck. The draw-bar pull curve springs abruptly from its datum line to a high peak, thus showing the extremely large tractive effort required to start the train. The buff curve of course assumes its zero position at this time, that is, as soon as the slack is drawn out between the locomotive and the remainder of the train.

As soon as the initial start has been made, the chart records begin to register the various conditions present during the acceleration of the train. The speed curve gradually rises from its axis, drawing farther and farther away from that line as the train gathers headway. At the same time, the draw-bar pull curve gradually falls in a series of decreasing peaks or saw-teeth, the reduction being due to the smaller tractive effort required as the train comes up to normal speed. The saw-tooth structure of the curve shows a cyclic variation in draw-bar pull, each of the teeth or cycles denoting one revolution of the locomotive drivers. The distance-traveled diagram, No. 3, resumes its customary record of wheel-revolutions. The steps of the time diagram are at first very short as measured along the length of the chart, but, as was explained before, increase in length as the speed of the train increases. The cab diagram gives record of the throttle and reverse lever positions, which, as shown, are changed frequently during starting. The first notation, 1½—203—14s, shows that the throttle is initially opened 1½ quarter-inches, or three-eighths of an inch, as measured on the steam, the steam pressure is 203 pounds per square inch, and the reverse lever is 14 notches ahead of center. The letter "s" at the end of the notation indicates that the locomotive is started under single expansion, and a later offset shows where this condition is changed to compound. The successive offsets and notations on the diagram exhibit the respective



changes in the throttle and reverse lever during a varying-speed period of running. The mile-post diagram records the passing of the station of Barlington Junction at 9.57:30, and later of mile-post 62. From this point onward, the train may be said to be traveling at normal speed, and the chart records re-assume their forms of the first period.

Testing Equipment

The next phase of the subject to be taken up is that of the testing equipment by which a chart is made. Of the dynamometer car as a whole, it is unnecessary to speak, as its principal features have been incidentally explained in the foregoing discussion or are shown in the accompanying pictures. The measuring and recording apparatus is of interest however, and will now be considered in its schematic form, particularly as related to the chronograph.

A schematic layout of the chronograph is shown in Fig. 5, to which the reader is referred. As is indicated, the machine consists primarily of the chart-making apparatus, that is, the recording instruments with their pens, and a means for driving the chart; besides this apparatus, other devices are built into the chronograph, but merely for convenience in construction or operation. The machine is made up of a table upon which the recording apparatus is mounted and beneath which the means for driving the chart is located. The blank chart paper constitutes the supply roll, A, at the back of the table, from which roll the strip extends across the top of the table, passing under the recording pens, and is rolled as the completed chart onto the chart roll, B, at the front of the table. In the movement of the paper under the pens, each pen leaves a trace and these traces constitute the chart records or diagrams. The two means of chart drive are illustrated, the two sources being an electric motor, for use when the train is stationary, and a system of transmission from one of the car axles, for use when the train is in motion. By a set of gears, not shown in the figure, the chart travel is always from right to left (as seen in the figure) whether the car be moving forward or backward. The reader should bear in mind that Fig. 5 throughout is a schematic rather

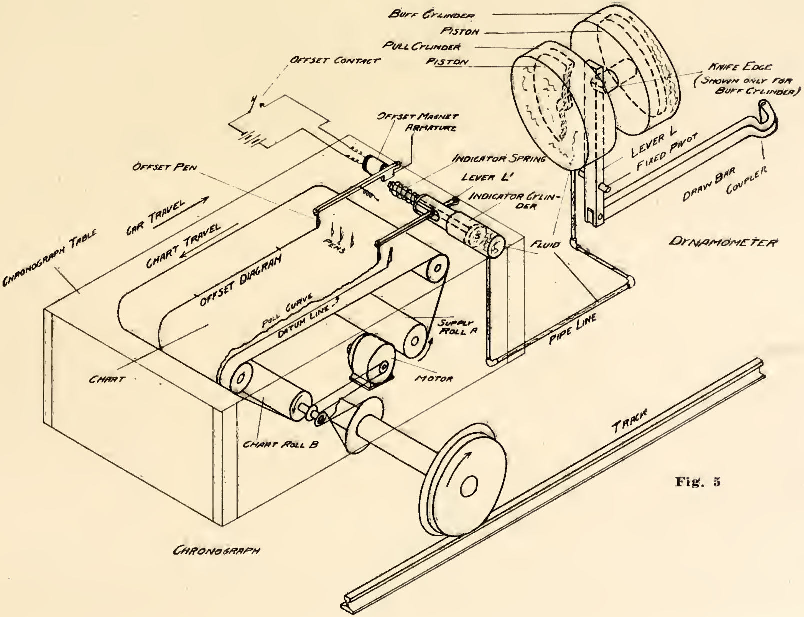

BUFF CYLINDER
PISTON
PULL CYLINDER
PISTON
OFFSET CONTACT
KNIFE EDGE (SHOWN ONLY FOR BUFF CYLINDER)
OFFSET MAGNET ARMATURE
LEVER L
FIXED PIVOT
INDICATOR SPRING
LEVER L'
INDICATOR CYLINDER
DRAW BAR
COUPLER
OFFSET PEN
CAR TRAVEL
CHART TRAVEL
PENS
FLUID
DYNAMOMETER
CHRONOGRAPH TABLE
OFFSET DIAGRAM
PULL CURVE
DATUM LINE
SUPPLY ROLL A
PIPE LINE
CHART
MOTOR
CHART ROLL B
TRACK
CHRONOGRAPH

Fig. 5

than an actual arrangement; it merely illustrates the underlying principles of the actual machine.

Of the individual functions of the chronograph, only two are shown in detail, namely, the apparatus for measuring and recording draw-bar pull, and one of the momentary-offset movements. Consider the former device, the fundamental plan of which comprises a machine called a dynamometer, by which the draw-bar pull sets up a pressure in the fluid of a hydrostatic system; this pressure is measured and recorded on the chart by a device very similar to an ordinary steam-engine indicator.

The dynamometer consists first of a vertical lever, L, pivoted just below the car floor, the lower end of which lever is joined to the draw-bar. Inside of the car and on either side of the upper end of the lever is a cylinder. Each cylinder is fitted with a piston, whose rod, by a knife-edge contact, engages the upper end of the lever, L. Each cylinder is filled with oil so that a push or pull on the draw-bar, through the agency of the lever, L, and the pistons, establishes a pressure in the fluid of one cylinder or the other. This pressure is obviously proportional to the force acting on the draw-bar.

By means of pipe lines, each of the cylinders is connected to an indicator on the chronograph which indicators serve to measure and record the pressures in the form of the draw-bar curves on the chart. The two indicators are similar, and hence but one is shown in Fig. 5, and only this one will be discussed; the indicator illustrated in the figure is the one used for draw-bar pull.

The draw-bar pull indicator consists of a standard Crosby outside-spring indicator without the usual revolving-drum recording device. Instead of this recorder, the piston rod is attached to one end of a lever, the opposite end of which carries the recording pen. Any pressure in the hydrostatic system displaces the piston of the indicator against the action of the indicator spring, so that the movement of the piston is directly proportional to the pressure; this pressure, in turn, is directly proportional to the draw-bar pull, so that the piston movement is a measure of this pull.

These measurements are recorded in the form of the draw-bar pull curve by means of the lever, L^1, and the recording pen. This lever transmits the piston movement to the curve-drawing pen, so that the transverse movements of this pen are proportional to the piston displacements and hence are a measure of the draw-bar pull. It is, of course, necessary that a datum pen be provided, marking the position of zero pull; or, the position of no displacement of the curve pen. In this manner, the diagram of draw-bar pull is formed. The actual appearance of the recording apparatus is shown in the accompanying photographs of the chronograph.

As was previously stated, a similar arrangement serves to record the draw-bar pull.

The speed of the train is measured by a Boyer speed recorder, working in conjunction with one of the chronographs. The details of this apparatus need not be taken up here.

The air-brake pressures are measured and recorded by indicators similar to those used in the draw-bar apparatus. One of these indicators is connected by a pipe to the train line of the brake system, whereas the other is connected to the brake cylinder of the dynamometer car; the respective air pressures are measured and recorded in exactly the same way as the pressure in the hydrostatic systems of the draw-bar apparatus.

Consider now those diagrams involving offsets. The scheme by which momentary offsets are produced is clearly shown in Fig. 5. As is illustrated, the pen making the diagram is carried on the front end of a lever which is pivoted at its opposite end to the frame of the machine. At an intermediate point along this lever is mounted a soft iron block. This block forms the armature of an electro-magnet, mounted upon the frame of the machine just to the left of the armature. A plan of the electric circuit of the magnet is also presented, this scheme comprising the winding of the magnet, a battery, and a control contact. The lever carrying the pen is normally held away from the magnet by a spring.

In the operation of the device, the control contact is normally open and the magnet is de-energized. Under these conditions, the straight-line or major portions of the offset diagrams are drawn. If the control contact be closed, the magnet is energized and the lever, together with the pen, is drawn toward the magnet. Upon the release of the contact, the magnet is de-energized and the lever and pen are drawn back to their original positions by the spring. In this way, an opposite or cross-mark is formed in the diagram. The control contact may be a push button or the commutator device of the distance-traveled records.

A similar arrangement is utilized in the forming of multiple offsets except that a rachet device is added to the mechanism, by means of which the lever and pen are moved by steps from their extreme-left position to the opposite extreme, and are returned to the initial location by one large step, as was previously described. It is not necessary to consider the mechanical details of the device. In the multiple offset type of records, the control contact is a push button in the case of the coal recorder and a clock contact in the case of the time register.

The apparatus taken up in the foregoing treatment includes the essential features of the testing equipment; in the concluding paragraphs of this article will be considered some of the more important uses of a dynamometer car.

The first use of a dynamometer car is, of course, in the performance tests of locomotives, and as this work has already been discussed it need only be mentioned at this point.

A second class of locomotive tests, which constitutes an important phase of the work is what is known as tonnage tests. These are for the purpose of determining the maximum load which an engine can haul over a particular section of track without exceeding the rating of the machine. Such ratings are given as so many pounds pull on the draw-bar at a specified rate of travel. The chronograph record provided by a dynamometer-car test shows the actual work being done by a locomotive and consequently whether the locomotive is working at its maximum rating or not.

A third class of tests includes the experimental work done upon the mechanical equipment of a train other than the locomotive, and involves more particularly tests performed on the air-brakes. Such experiments have their own peculiar features which govern the character of the tests performed, so that this work cannot be considered in detail in this article.

A fourth important use of a dynamameter car is in connection with the sub-dividing of train-operating expenses, that is, in costs determinations. Such determinations are used not so much in the accounts of the company as in the determination of freight and passenger rates, and are hence known as rate cases.

In rate cases, the expense of each class of operations of a train is to be ascertained, typical divisions being the expense incurred during the actual running time of a train; expense of switching cars; expense of stops made for the loading or unloading of freight (or passengers); expense of stops made for taking coal, water, to receive orders or any of the stops necessitated by the train-operation itself; and numerous other divisions of expense which are desirable in the calculation of rates. It will be noted that some of these expenses depend largely upon the work done by the locomotive, for example, the cost of fuel burned; whereas other expenses depend upon the time which elaps during a class of operations, for example, the wages of the crew and perhaps certain fixed charges against the rolling stock. For these reasons, one of the essential factors in rate determinations is a chronographic record of train operation, and consequently the dynamometer car molds an important place in the work.

The work of the dynamometer car comprises a series of test runs made with each of the trains concerned in the rate determination; during these runs, particular attention is paid to the reason for each train operation and to the number of cars involved. The result being chronographic records furnish the basis for the distribution of total operating expense among the various items going to make up this total. The tests are usually extensive, covering an entire state or more, so that the data in the aggregate furnishes a good indication of train operation, although many of the individual records may be in error due to a temporary unbalance of transportation conditions.

From these few examples one may see what an important function a dynamometer car may perform in the operation of a railroad.

FACTORS IN VENTILATION

BY W. O. ARMSPACH*

Ventilating Engineer, Health Dept., City of Chicago.

The relationship between the health of occupants and the methods of ventilating a building is a matter of sufficient importance to warrant the obtaining of exact data upon which to base our opinions as to the value of either the natural system or the mechanical type of ventilation. For many years we have had a controversy between the advocates of these two types of ventilating systems, some engineers being in favor of the plenum or exhaust systems, and again others who claim that natural ventilation is sufficient in all cases.

It is obvious that many mechanical systems are unsatisfactory, but this is usually due to faulty design or unintelligent operation. Then again we hear complaints of bad ventilation where the natural system is used.

It is evident that if correct conditions are produced and maintained in a room it is immaterial whether a natural or a mechanical system is employed to obtain these conditions. If the requirements are clearly understood by the designer of a system then there is no reason why, with all our modern humidifing, tempering and air volume devices, that the correct conditions of ventilation cannot be maintained in any room.

The science has now reached a point where it is clearly understood what factors are injurious to the health and comfort, and also the conditions necessary for good air. These factors can conveniently be divided into three classes:

First—Physical, or those affecting heat dissipation from the body.

Second—Chemical, or those pertaining to the impurities in the air.

Third—Physiological, or those affecting oxidation through the lungs.

In class one are temperature, humidity and air motion. Class two includes dust, bacteria and odors, and three the air supply and carbon-dioxide. These three groups include all the known factors which affect the air conditions in a room and will be taken up separately.

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*Class of 1917

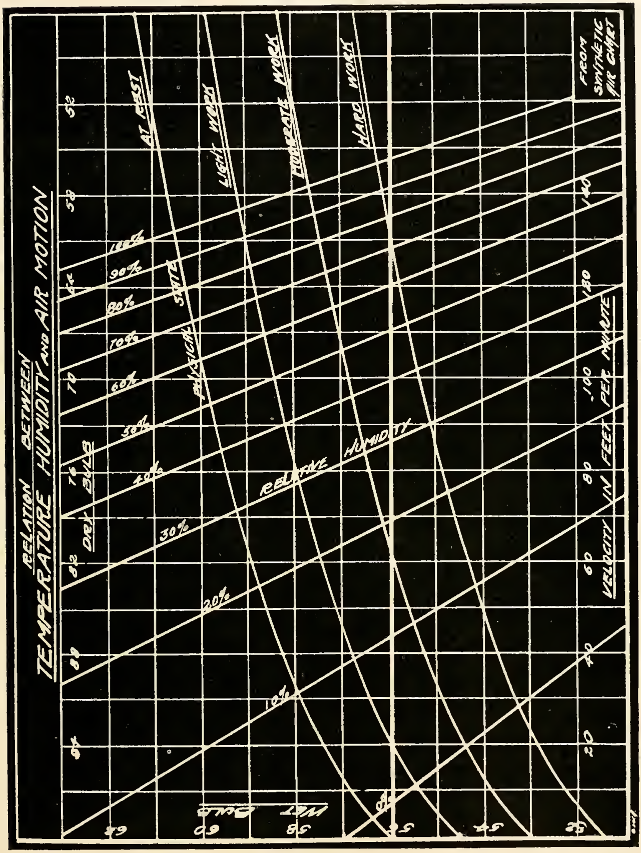
RELATION BETWEEN
TEMPERATURE HUMIDITY AND AIR MOTION
DRY BULB
52
58
64
70
76
82
88
94
AT REST
LIGHT WORK
MODERATE WORK
HARD WORK
PHYSICAL STATE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
RELATIVE HUMIDITY
FROM SYNTHETIC AIR CHART
VELOCITY IN FEET PER MINUTE
20
40
60
80
100
120
140
WET BULB
62
60
58
56
54
52

Fig. 1

Temperature, Humidity and Air Motion

The comfort of the body is a direct function of the heat loss from the body, and therefore is dependent upon the temperature, humidity and air motion in the room. This relation has been thoroughly investigated by the Chicago Commission on Ventilation and the chart shown in Fig. 1, was the result. Observers were placed in cabinets in which the temperature and humidity were changed, and they were required to state whether they were warm, cool or comfortable. In nearly every case the observer recorded a feeling of comfort when the wet bulb temperature was 56 degrees, this being independent of the dry bulb temperature. By increasing the dry bulb temperature we must lower the relative humidity to maintain a condition of comfort, and a wet bulb of 56. The observers wore ordinary clothing, were at rest, and the air motion was zero. By changing the physical state from at rest to light work it was found that the wet bulb temperature must be lowered one and one-half degrees to maintain a condition of comfort. The same was found to be true in changing from light to moderate work and from moderate to hard work. Now by increasing the air motion the wet bulb must be higher to give a normal heat loss from the body, and therefore a feeling of comfort. The results of these observations have been plotted as is shown in Fig. 1.

We note from the tests that the wet bulb temperature is the determining factor for comfort, and that the comfortable wet bulb increases with the air motion.

Dust Bacteria and Odors

The cause for complaints of poor ventilation have many times been found to be due to the fact that the air contained an exceptionally large number of dust particles. These particles, varying in size from those visible under the microscope to those easily seen floating about in the air, find their way into the rooms through windows, dirty ducts and improperly located inlets, and if in large numbers cause a great inconvenience to the occupants. There are several forms of instruments now on the market designed to determine the amount of dust in the air. The one used by the Ventilation Division of the Chicago Health Department

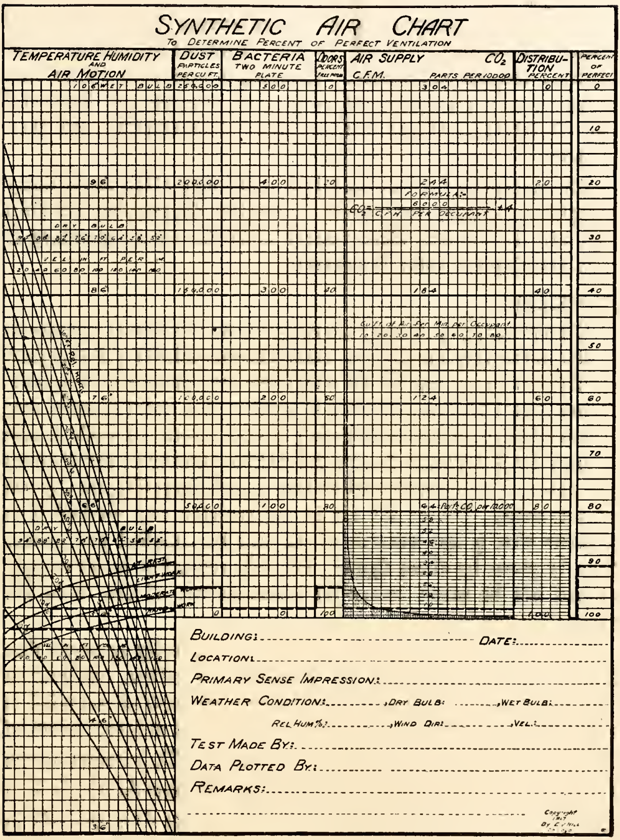
SYNTHETIC AIR CHART
TO DETERMINE PERCENT OF PERFECT VENTILATION
TEMPERATURE HUMIDITY AND AIR MOTION
DUST PARTICLES PER CU. FT.
BACTERIA TWO MINUTE PLATE
ODORS PERCENT
AIR SUPPLY C.F.M.
CO2 PARTS PER 10000
DISTRIBUTION PERCENT
PERCENT OF PERFECT
WET BULB
DRY BULB
VEL. IN FT. PER M.
AT REST
LIGHT WORK
MODERATE WORK
HARD WORK
FORMULA: CO2 = 6000 / C.F.M. PER OCCUPANT + 4
Cu. Ft. of Air Per Min. per Occupant
64 Parts CO2 per 10000
0
10
20
30
40
50
60
70
80
90
100
BUILDING:
DATE:
LOCATION:
PRIMARY SENSE IMPRESSION:
WEATHER CONDITION:
DRY BULB:
WET BULB:
REL. HUM %:
WIND DIR:
VEL.:
TEST MADE BY:
DATA PLOTTED BY:
REMARKS:
Copyright 1917 By C. V. Hill

Fig. 2.

and designed by Dr. E. V. Hill, affords a very quick and convenient method of counting the dust particles.

A high dust count usually means a high bacteria count, and while these are likely to be of the non-pathogenic variety they should not be present under the best ventilated conditions. The bacteria cultures are made by exposing a four inch Petrie dish prepared with an agar solution for two minutes and incubated for 48 hours at room temperature. The colonies are then counted.

The presence of a bad odor in a room may often cause many complaints of poor ventilation. All other factors may be ideal and still the air conditions appear to be far below standard if even the slightest odor is present.

Air Supply

The air supply is usually based upon the number of occupants in the room, varying from 20 cubic feet per minute per occupant in chuches to as high as 80 cubic feet per minute in hospitals. It sometimes happens that the character of a room is such that the number of persons occupying it may vary. In such a case enough air is supplied to give the proper number of air changes per hour. This number varies from 2 to 6 depending on the use of the room. Where the air is re-circulated and washed it is possible that a less amount of air can be supplied per person than is given by these figures, but this reduction in air supply should not be made unless the requirements of the room are thoroughly understood.

The carbon dioxide content in the air is usually so small that it is neither disagreeable nor harmful. It offers, however, a valuable index in determining the amount of fresh air supplied to a room, and also the amount of air received in different parts of the room. Knowing the average amount of CO_2 exhaled by the occupants, and knowing the amount in the outside air, it is a simple problem to determine from the average CO_2 analysis in the room the fresh air being supplied. By taking several samples in different parts of the room and finding the deviation of the analysis at these locations from the average in the room the distribution of the fresh air can be determined.

The Synthetic Air Chart

All the factors affecting the physical, chemical and physiological properties of the atmosphere have been discussed, and the extent to which they are present can be determined by the use of various instruments. The different factors can all be plotted upon the Synthetic Air Chart shown in Fig. 2 which was designed by Dr. E. V. Hill. All the factors are given an appropriate weight and divided into the proper groups. Each group is complete in itself and embraces conditions from ideal at the base to unlivable at the top of the chart. It will be noticed that at the base of group 3 we have four parts of CO_2 or an infinite amount of fresh air, being outside conditions and ideal as far as the air supply is concerned. At the top of this group we have 304 parts, or a condition in which life would cease to exist. The worst condition in this group would cause the percentage of perfect shown in the last column to be zero. In the same manner the condition shown at the top of either of the other two groups would cause the percentage of perfect to be zero. Each of the three parts of the chart originally contained 1000 squares, but 100 were taken from each group and placed in the last column to take care of distribution.

In using the chart we proceed as follows:

From the test data we note the wet bulb temperature. This is indicated by the horizontal line connecting this wet bulb temperature and the appropriate air motion curve. We next note from the test data the air motion that prevailed and connect by the horizontal line this point on the air motion curve with the wet bulb that is desired for this velocity. The number of squares between these two horizontal lines across this portion of the chart is the amount of penalization for this factor. The remainder of the data is plotted with a horizontal line at the proper distance above the base according to the results of the test. To determine the percentage of perfect ventilation, the number of squares that fall below the test line which is plotted across the chart are subtracted from 1000, and the result recorded in the last column headed Percent of Perfect.

Methods and Instruments

TEMPERATURES: Temperatures are determined by standard thermometers located at representative positions in the room.

The sling psychrometer is used to determine the relative humidity.

AIR ACTION: The velocity of the air in a room can be found by the use of an ammonium-chloride apparatus. This consists of two bottles, one containing hydrochloric acid and the other ammonium-hydroxide, arranged with rubber tubing so that air will be forced through both bottles by pressing a rubber bulb attached to the end of the tubing. This causes ammonium-chloride fumes to pass from the bottles and indicate the direction and velocity of the air. The velocity is noted with a stop watch.

DUST: The dust content in the room can most conveniently be determined with a Hill Dust Counter. This method makes a permanent record so that the particles can be counted and studied at any time.

BACTERIA: The number of bacteria in the air is found by exposing the standard Agar plates for two minutes in several representative locations in the room and developed for 48 hours at room temperature.

ODORS: The percentage of freedom from odors is determined by the impression received by a person upon first entering the room from outdoors.

AIR SUPPLY and CO_2: If a mechanical system is used the supply is determined by anemometer readings taken at all inlet registers. This is also checked by results obtained from the average CO_2 reading.

DISTRIBUTION: The percentage of distribution is determined from the CO_2 readings in different parts of the room, by finding the average variation from the average. The CO_2 determinations are made with a cautery bulb and a 125 cc. rubber stoppered bottle. The air samples should all be taken in the breathing zone.

"I am not bound to win, but I am bound to be true. I am not bound to succeed, but I am bound to live up to what light I have. I must stand with anybody that stands right; stand with him while he is right and part with him when he goes wrong."

—Abraham Lincoln.

Engineering is a noble calling and the men who follow it need not necessarily, if they so mind, be swallowed up in a sea of materialism. Matter is universal and clothes the seat of thought and spirit. In molding matter to the uses of man the engineer but adapts himself to the conditions of a material world. The real engineer is the intellectual force and spirit back of matter. So far from being debased, he is to be congratulated that his mind may work in such close harmony with nature. His mental processes are sane and true, and drawing their inspiration from nature they find there an unlimited source. He need not be ashamed of his calling; let him see to it that he is worthy of it and that he uses the rich opportunity to grow into the full measure of manhood.

—Constant.

The Flag

This morning, as I passed into the land office, the flag dropped me a most cordial salutation, and from its rippling folds I heard it say: "Good morning, Mr. Flag Maker."

"I beg your pardon, Old Glory," I said, "you are mistaken. I am not the President of the United States, nor the Vice President, nor a member of Congress, nor even a general in the army. I am only a government clerk."

"Well, you helped to clear that patent for the hopeful inventor in New York, or pushed the opening of that new ditch in Colorado, or made that mine in Illinois more safe, or brought relief to the old soldier in Wyoming. No matter whichever one of these beneficent individuals you may happen to be, I give you greeting, Mr. Flag Maker."

"Yesterday the Congress spoke a word which will open the door of Alaska, but a mother in Michigan worked from sunrise until far into the night to give her boy an education. She, too, is making the flag. Yesterday we made a new law to prevent financial panics; yesterday, no doubt, a schoolteacher in Ohio taught his first letters to a boy who will write a song that will give cheer to millions of our race. We are all making the flag."

"But, I said impatiently, "these people were only working."

Then came a great shout about the flag.

"Let me tell you who I am.

"The work that we do is the making of the real flag.

"I am not the flag, not at all. I am but its shadow.

"I am whatever you make me, nothing more.

"I am your belief in yourself, your dream of what a people may become.

"I live a changing life, a life of moods and passions, of heartbreaks and tired muscles.

"Sometimes I am strong with pride, when men do an honest work, fitting the rails together truly.

"Sometimes I droop, for then purpose has gone from me and cynically I play the coward.

"Sometimes I am loud, garish and full of that ego that blasts judgment.

"But always I am all that you hope to be and have the courage to try for.

"I am song and fear, struggle and panic, and ennobling hope.

"I am the day's work of the weakest man and the largest dream of the most daring.

"I am the Constitution and the courts, statutes and statute-makers, soldier and dreadnought, drayman and street-sweep, cook, counselor and clerk.

"I am the battle of yesterday and the mistake of to-morrow.

"I am the mystery of the men who do without knowing why.

"I am the clutch of an idea and the reasoned purpose of resolution.

"I am no more than what you believe me to be and I am all that you believe I can be.

"I am what you make me, nothing more.

"I swing before your eyes as a bright gleam of color, a symbol of yourself, the pictured suggestion of that big thing which makes this nation. My stars and my stripes are your dreams and your labors. They are bright with cheer, brilliant with courage, firm with faith because you have made them so out of your hearts, for you are the makers of the flag, and it is well that you glory in the making."—*Address Made by Franklin E. Lane, Secretary of the Interior, to the Employees of his Department.*

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In order to maintain the present high standard with which the Armour Engineer is credited, it is essential that the loyal support which Armour men have extended to it in the past be continued.

Conditions due to the war have not only increased our publication prices and reduced our advertising subscriptions, but in addition they have reduced our list of subscribers to the book a very appreciable amount.

College engineering publications should not be permitted to fall below the standard set before the war; rather, they should be extended that they may serve as a bond between the men who are in the service and those who are preparing to enter.

Many of the alumnus are so situated that it would be an easy matter for them to provide the Armour Engineer with an advertisement, were they to make the effort. It is for them to realize that the staff requires their support, now more than ever before.

DELIGHTFUL! GO TO IT MAC!

(Signed) L. C. M.

Mr. Herbert W. Puschel,
Editor, Armour Engineer.

Dear Sir:

The last copy of the "Engineer" is here. I am glad you have an article now and then written in easy, semi-technical, semi-detailed English that a grandfather can muddle thru and still imagine he is reading the latest news. That Substation article made me hunt for a text book that was really modern. If you just stopped to think you must know that the books we lugged around in 1898 would not keep one of you present day fellows awake. There are words and terms used in the Substation article that the combined faculty of my day could not have defined. Billy Sims or Dick Sloan could have run all the Substation on the South Side in 1898 and kept up with the scholastic procession.

The internal combustion department was represented by a marvelous combuster that combusted thru a window on Armour Ave. at the rear end of the Mission. It always seemed to me that Flanders could make it cough a little harder than anyone else. We did not have a Chalmers 6-30 or even a Ford 4-18. I watched the historic auto race on the Midway, Thanksgiving Day, 1895. Got my picture in the "Herald" and helped push the winner to position for the start. Poor, dear Bunny Stevens had the first real auto around the Institute and we who had the chance to ride home with him came in pretty handy now and then and yes, often. He needed advice and real help.

Camp construction is something I can appreciate. Right along side Riverside we will hope to see an Aviation School fully equipped by the Government and running by early summer.

I wonder how that article on Entropy slipped in. Really I had imagined there was an end to it. But here is Professor Kerr turning a spot light on the darned thing. It is a shame to waste the space on it. Prof. Kerr really had good intentions but I am afraid if he is not kindly pulled away from such subjects that he will be writing poetry on Thermo Kultur. The Professor had true vision. He passed me in Thermo by the "grace of God." He said so and I never denied it. But, tho I respect his courage I have deleted pages 123 to 129 of the present issue. He must have an ally in V. A. Kerr.

Yes it is good to get these little reminders of our school days. My mind reforms so many pleasant pictures of the earlier days. I trust my boy to have as good a time in his schooling. I have forgiven the fellows for all the rough housing at the Frat rooms. Am sorry that more of my day are not in Service. The fellows of the present are our inspiration.

Yours sincerely,
H. A. MacClyment.

MANUFACTURING PRINCIPLES

BY MR. A. W. RAHN

Manufacturing Specialist, Western Electric Co.

In the analysis of this subject before men of the varied Engineering fields such as you represent, it seems that a conciliation between the subject and hearer might first be necessary in order that all of us may be in the proper attitude of being able to understand the magnitude of these principles, as applied in the business and economic world. The first point for consideration is—what is the relation of manufacturing compared to world enterprise. When we consider the evolution of man and the general scheme of economics, we find that the comfort of the individual and necessity as the "Mother of Invention" has ever been the factor that is predominant in history.

Men recognizing special abilities among themselves, found that one was more capable or proficient in the matter of hunting, another in the work of preparing the skin, another in the making of weapons, with the result that from the Paleolithic and Neolithic on down through the Middle Ages, men were becoming the servants of each other in the principle of creating, building and trading the results of their own labor. In every art and manufacture, the effects of the division of labor have been a continual evolution of one specific function which some individual has been called upon to perform. We see this principle working out today. The one who was proficient in hunting, fishing, building, etc., creates a supply of a commodity or services, and the individual seeking those services comes to the one of whom he desires the services or commodity. Naturally there is an increase over the amount required by the creating individual and an increase in the quantity of work to be performed by the creating individual. The greater this increase in the quantity of work to be performed, which in consequence to the division of labor increased the number of people performing this immediate function involves *first*—the increase in the dexterity of a particular workman; *second*—the saving of time which is commonly lost in passing from one specie of work to another; *third*—the invention of automation or machines to abridge labor and enable one man to do the work of many.

The first principle, namely, the increase of the dexterity of a particular workman, increases as the quantity of work increases which he is given to perform, so that in the division of labor, by reducing every man's business to some one simple operation and by making this operation the sole employment of his life, the dexterity of the workman is increased. This is a fundamental and needs no further explanation. *The second principle,* namely the saving of time lost in passing from one specie of work to another. The physical senses do not conceive and adapt themselves to changes and extremes of work as readily as when they are harnessed and trained toward one specific end, and thus it is that men have taken to one trade, profession, or vocation. *The third principle,* the abridging of labor by means of automation. It was not long for man to find that physical automation of the sameness in motion was irksome and tiresome, and that this fatigue could be overcome by maintaining these notions by energy other than that of the arm or leg. The story so runs about the first fire engines. A boy was constantly employed to open and shut alternately the communication between the boiler and the cylinder according as the piston either ascended or descended. One of the boys who enjoyed his play observed that by tying a string from the handle of the valve which opened this communication to another part of the machine, the valve would open and shut without his assistance and leave him at liberty to divert himself with his playmates. The boy wanted to save his own labor. This is merely one instance that will bring to our minds the thought that man comes to efficiency in seeking the law of least resistance, particularly in that phase where the automation is retarded by means of fatigue. With these few principles before us we are aware that our present day business is only in the evolution of the arts and sciences, and that the manufacture of today is but an enlargement of the individual functions which were at one time the original combination of skill, dexterity, and duty of one individual.

Today that individual has only one phase of that which originally was a combination of trades and professions. The division of labor has also created another power—the power of exchange. On account of the division of labor one man has more of a certain commodity than he has occasion for, while another has less. In order that the two individuals may exchange, even though the commodity in the possession of both may be desired by only the one, the other, of course being willing that he should have it, it is necessary that there be a *value* which would be of service to both. The result is money in its present form. The subsequent outgrowth of these fundamentals at this period are the *manufacturer,* the *merchant* and the *customer.*

The unification of the creative forces of making wares or material products by hand or machinery carried on systematically with the division of labor, permits us now to apply such principles in the manufacturing of wares.

The corporation of today is a body united for the purpose of producing and selling originating in the fact that some commodity may be placed on the market and that the principle of investment will be recompensed by the profit which seems to have made this venture a desirable one. The first step is organization.

The stockholders are those who have invested their money, and supply the capital of a company or corporation. They control the situation in the outset, as a rule in the proportion to their holdings. They elect a board of directors to represent them and control that which they desire to be put into effect to the end of a profit on their investment. The board of directors elect from their midst a president whose duty it is to see that the desires and results in accordance with the agreements are subsequently outlined and followed. Below this office is generally the starting point of the physical point of an organization, and that organization may be regarded the human machine by which natural powers are directed upon materials, in order to produce the desired results.

Of course, whether an organization is originated on a large or small scale is dependent upon the extent of the production planned. The logical corporation is that starting on a small scale and developing according to sales and profit which permit a wider range of diversity than may be possible in the inception.

In the main there are two classes of organization usually to be found, or from which, as a basis, they are deviated or combined. These are—the staff and line organization. The line organization is a plan under which each group of workmen receive their information from one foreman. This foreman is supervised by one man in the office of a superintendent. In this type of organization there is an inclination to become inefficient as business increases because of the fact that one man soon becomes an overworked, inefficient executive as he finds it necessary to direct in detail the destinies of the sales, shop and administration. And as the corporation grows the development resolves itself toward the staff organization. This type of organization is composed of men who are specialized in the various endeavors of the company's entire manufacturing field. The desired qualifications of men of the various capacities are those who control the functions assigned to them, e. g., a technical superintendent, operating superintendent, production superintendent, etc.

Mr. F. W. Taylor is the great advocate of this line of organization. However, it is seldom possible to follow his theories and fundamentals. On the other hand he is too often misconstrued and censored unjustly, as, I believe, Mr. Taylor is thorough authority on the subject of organization and to me it seems that men do not realize and appreciate the fact that he has dealt with fundamentals rather than with concrete cases applicable to every and any organization. In the origin of any business enterprise we find that the start will be small, inefficient and in general the attitude of "proving in" requires years of hard plugging. Further, the increase and extent in organization is generally governed by the increase in sales and increase in output. As the calculated level has been reached where it had been planned to break even, the thoughts may be turned to prepare to the next venture of increasing production and naturally preparing by reorganization. The start of any corporation is always more or less a connundrum as regards the extent of the adventure and the fundamentals are mostly in the hands of one or two individuals. It seems each one of us by dealing in and observing the fundamentals which are necessary to a developed corporation will also be applicable to any of the smaller sized companies. The true fundamental of all organization is to define the scope and action of units in a company, or whatever organization requires a defining of duty. To unite functions and to interlock a sufficient amount of responsibility one toward another, to insure harmony, promptness, and confidence in system is the field which must be covered in order to efficiently maintain and to derive the benefits of organization.

HOW TO PREPARE OUR UNCALLED MAN POWER

BY J. J. SCHOMMER

Instructor of Chemistry.

Red war has gripped this nation. From experiences the last four years it appears that it will be a long one. The nation must sacrifice its man power to attain its ideals. Much has been said about engineers, resources, officers, and equipment, yet in the last analysis it is man power that is going to win this war for us and our allies.

What are we doing to aid this man power that has not yet been called to the draft? What is the physical condition of our man power between the ages of 16 and 21? Why is so much stress put on the athletic games and physical culture work in all our cantonments? How can this uncalled man power be prepared beyond comparison without interfering with industrial and educational fields?

Ninety per cent of the young men between ages of 16 and 21, according to statistics, are doing no systematic athletic work. For these ninety per cent nothing is being done to prepare their bodies and spirit for the ordeal. Their call will come and six months training will find them in the trenches with barely enough military training and very little physical training.

One has only to consult the enormous records of rejected men and to look at the numbers of men in camp, to realize that the physical condition of our youth is very poor.

They lack agility and co-ordination. Their muscles are undeveloped. Their weight is below normal. Their spirit to fight undeveloped.

Who makes the best soldier? The athlete! Ask any of the camp instructors at the cantonments. Ask Germany! Germany has not trained her youth in marching and physical exercises in the gymnasium long before their entrance to the army, just for a fad. It is efficiency for war purposes. The writer met bands and bands of students on the march, ostensibly for sight seeing, throughout Germany in 1910. These young men were from 10 to 16 years old.

Why has our Government installed physical instructors at all the camps and behind the lines of battle? Time is precious now. Isn't it a waste of time to play baseball, football, basket ball, and devote hours at running and gymnasium exercises? Couldn't the time be spent more advantageously at drilling? No!

Of the most precious time necessary to fit out legions with military training time must be spent to build up the system and afford at the same time relaxation. The running and gymnasium exercises build up the system to which the games also contribute. The games condition men as no amount of drilling can do. It is intensified drilling a thousand times without all the thought of hard work. It is play and relaxation.

I have spoken to men of the big universities in the West and East and to men in the army in regards to the value of military training and athletics to the young men between the ages of 16 and 21.

It is nearly a unanimous opinion that two years military training as given in colleges, schools and national guard, can be duplicated in 3 to 4 weeks of intensified training. Can anyone duplicate the results of the same time spent in physical training in 3 or 4 weeks by intensified work? No! Building up the human system is slow work, but once built up by the proper physical exercise outdoor or indoor, between the ages of 16 and 21, when one is most susceptible to this training, it is easy to keep oneself in good condition throughout life.

Our American games are stepping stones to the game of war. Everything in them tends to develop the spirit, subjection of self for the gain of the whole. This is also grand discipline, and the very best of moral training. For once interested in team play, one becomes thoughtful of the body to aid in the highest degree in team play.

Again in baseball a man "sacrifices" himself to advance a runner to a position of scoring to aid the team. This same spirit is called on for a company of men to sacrifice themselves in battle to advance the regiment or allow its retreat. The speed, endurance and agility in running bases, the batting eye and the gauge of distance all play their part in the game of war.

Bomb throwing calls for good eyesight, gauge of distance, and a good arm to throw with. Speed, endurance, and agility is everything in bayonet practice. A slow man stands no chance in the quick thrusts and parry of bayonets. Endurance means much when one is forced to advance and fight half the night, and all day, and still have enough in reserve to fight like a devil to hold what is won in a counter attack.

And what of football, the greatest of all American games? Its whole scheme is war. The massing of two to four men on one, to open a hole for the carrier of the ball, is similar to massing a preponderance of men to break through or capture a position. The feinting of men to delude and pull defensive men out of position so as to make an attack on a weak side is constantly done in warfare, excepting that whole divisions play their part instead of a few men. And, so the writer could go on and on to point out examples, but enough has been said to point out the value of games and exercise.

To make every youth between 18 and 21 years take 3 years of his whole time to drill and get himself into splendid physical condition, of course, would be the real sort of training. This however, would be too much at present to ask. Therefore, to not interfere seriously with education and industry, all our youths between 16 and 21 years should be made to participate an hour to two hours a day first in gymnastic exercises and then athletic games, to build up the body to its highest efficiency.

Further, during this time, every Saturday they should be enforced to go to the rifle range and learn the parts of a rifle and to shoot. Further, an hour or two a week could be spent in evening classes or in the high schools in learning military organization and its many details. If this program is followed our men when called to the colors would be fit in physical condition, rifle practice, and spirit, and by intensified training could be sent to the trenches in quicked time and would make wonderfully efficient soldiers.

SIGNAL CORPS RESERVE

Several months ago the Institute opened evening classes for teaching men to send and receive signals such as are used in wire and wireless telegraphy. The object of this instruction was to aid men who might be called in the military draft in becoming practical operators so that they might render effective service in the signal corps of the army. Recently, a new course has been started which is being taken by senior college students and which is concerned mainly with the theory and practice of wireless telegraphy. This course covers a period of about fifteen weeks and is intended to assist men in preparing for research and for field service with the army. The work is of college grade, and the men who finish the course successfully may join the signal corps and receive further instruction in the same general line before taking up active duty.

E. H. Freeman.

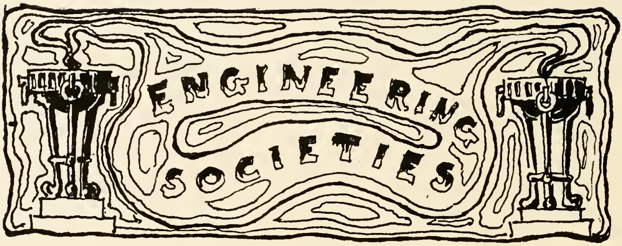
EXTRACTS FROM REVIEW OF FIFTH EDITION OF PROFESSOR GEORGE F. GEBHARDT'S BOOK "STEAM POWER PLANT ENGINEERING"

Few books are more highly valued among power-plant men than this one, the first edition of which appeared nearly ten years ago. Its wide use is its best commendation, especially when one reflects upon the remarkably rapid development in this field during the last decade. As the author says in the preface to this latest edition: "Revisions in 1909, 1911 and 1913 failed to keep pace with the art, and the task of recording correct practice appeared to be a hopeless one." He puts out the new adition, rewritten in great part, believing that radical changes are not likely to come in the immediate future. He has aimed, therefore, to produce a general work of stability, one, which, assumbably, he believes will present current practice for some time to come without the frequent editions which events of the past have made necessary. That Mr. Gebhardt is sound in this belief is the opinion of the reviewer. Certainly, no new types of prime movers of such revolutionary character as the steam turbine and "express" stokers and boilers are in sight on the horizon; and as the author has excellently covered these and allied subjects, he likely has put his work in more stable form than it has ever been.

The most conspicuous additions to the work are the new chapters on Elementary Thermodynamics, Properties of Steam and the Properties of Dry and Saturated Air.

Mr. Gebhardt has greatly enlarged upon his treatment of fuels and combustion. Suffice it to say that in this latest edition he has presented the most suitable treatment of these subjects, judged by the needs of power-plant men, that the receiver has ever found, even in books devoted exclusively to fuels and the theory and chemistry of combustion—the theory and chemistry, mind; not those details of technique of combustion as it must be carried on in boiler furnaces. For these he refers the reader to articles in engineering periodicals, and the references are many.

This fifth edition is indeed a creditable work and the receiver regrets that space forbids more about it here. The subjects embraced are so numerous and well presented that only in rare instances does one care to criticize; but, rather, to suggest at these places, realizing the enormity of the fatiguing task of compiling such numerous and varied data. Chapter XVIII, pp. 849-890, on Finance and Economics—Cost of Power, is, in the reviewer's mind the best extract. Mr. Gebhardt is to be congratulated. —Power, Vol. 47, No. 11.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President	K. A. Taylor
Vice-President	J. A. Keith
Secretary	V. A. Kerr
Treasurer	H. Anderson

Meeting was called at 7:30 in the Engineering Room in Chapin Hall. It decided to hold the next meeting on Tuesday night, April 2nd, and to have an outside speaker. President Taylor assigned Messrs. Weinshenker, Andre and Swartz for short talks on some engineering subject for that evening in case the speaker was not available. Mr. Anderson, treasurer, reported all debts paid and a balance in the treasury. Mr. Neilson gave a very interesting talk on the use of Steam turbines with reciprocating engines as a means of propulsion for ships.

Mr. Lunde talked on the design and manufacture of piano hardware, illustrating his lecture with the various pieces of hardware in the different stages of their development and explaining the operations leading to the successive stages. Mr. Carlson gave a talk on a new type of machine for coast defense, illustrating with sketches on a blackboard. Mr. Kerr gave a talk on the qualities and method of manufacture of Byers' Wrought Iron Pipe. He illustrated his lecture with lantern slides, showing the necessary operations for the production of the pipe. Meeting adjourned at 9.05.

V. A. Kerr, Secretary.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Chairman	R. A. Newlander
Treasurer	H. H. Shotwell
Secretary	A. A. Hofgren

The sixth meeting of the year 1917-18 was held jointly with the Armour Civil Engineering Society of Feb. 19th, 1918. Mr. A. W. Rahn, a "Manufacturing Specialist" of the Western Electric Co., gave a talk on "Manufacturing Principles." The text of which is given in this issue of the "Engineer." A general discussion followed the talk which proved very instructive.

A. A. H.

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	J. Nitka
Vice-President	H. A. Peterson
Recording Secretary	L. Weiss
Corresponding Secretary	B. B. Cramer
Treasurer	V. M. Crown

The third meeting of the Armour Civil Engineering Society was held December 4 in the Engineering Rooms of Chapin Hall.

Professor Dean gave a very interesting and instructive talk on "The Construction of the Sixth National Army Cantonment at Camp Jackson, South Carolina."

The last meeting of the Armour Civil Engineering Society was held Tuesday, Feb. 26, 1918, at 7:30 P. M., in the Engineering Rooms at Chapin Hall.

This meeting was given in conjunction with the Armour Branch of American Institute of Electrical Engineers.

The speaker of the evening, Mr. Rahn, gave a very instructive talk on "Manufacturing Methods." Many interesting points were given on Methods used in Manufacturing Problems.

B. B. Cramer.

THE CHEMICAL ENGINEERING SOCIETY ARMOUR INSTITUTE OF TECHNOLOGY

President	F. R. Johnson
Vice-President	C. W. Muehlberger
Secretary	W. W. Koehler
Treasurer	A. Pearson

Recently there has been added to the Industrial Laboratory a substantial stone top table, a set of adjustable rolls 8x20 inches and several pieces of smaller apparatus.

Arrangements are being made with several of Chicago's prominent chemists for addresses during the coming month.

W. W. Köhler.

THE FIRE PROTECTION ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	T. Trask
Vice-President	L. Kuttnauer
Secretary	R. Mann
Treasurer	C. Mintz

On March last the entire Sophomore class held an inspection trip to the Underwriters Laboratories, the testing station maintained by the National Board of Fire Underwriters, 207 East Ohio St. It is in this laboratry that the Junior and Senior students in the Fire Protection Engineering course are, with the cordial co-operation of the management, allowed the use of the testing facilities for their laboratory course. The students were escorted through the plant by Prof. Finnegan, who explained to them the many tests that were being conducted by the Laboratory engineers.

Among the more important tests witnessed was the fire and load test made on a fireproofed building column. The new column testing furnace, valued at $30,000, upon which the National Bureau of Standards, the Factory Mutual Insurance companies, and the Underwriters Laboratories are jointly conducting fire tests upon all types of building columns, was shown in operation with a column undergoing test.

An operation test made upon a 60-gallon chemical fire extinguisher designed for village fire department service was conducted by the Junior students. A demonstration of the discharge from a ridge pole sprinkler and an operation test of a 33-gallon chemical extenguisher, both of these being the subjects of theses upon which the Seniors are working, were conducted. Other features of interest that were shown the Sophomores were the chemical laboratory, the electrical laboratory, and the sprinkler laboratory. The trip was of especial interest to the architects as Underwriters Laboratories is perhaps the most completely fire-resistive building in the world and in its construction the Underwriters have gone to the extreme in making it a model of its kind. The office of the president, Mr. W. H. Merrill, caused comment for this office proves that, even though thoroughly fire-proof, offices can be made beautiful and harmonious.

For the purpose of fostering an interest in current events in the engineering world, especially along the lines of fire prevention and fire protection, and to create among the students a desire to keep up with the times, a permanent exhibition board has been placed in the room at the Underwriters Laboratories alloted to the Students in the Fire Protection Engineering course. Special exhibits calling attention to particular engineering and engineering achievements having a special "news value," photographs, maps, and other material illustrating engineering topics of the day are posted upon this board. The exhibits are changed very frequently and have proved to be a source of a great deal of interest among the students.

The field inspections, open to the Senior students of the Department, will begin about the first week in March. For the greater part they will have to do with special hazard risks which are selected as being typical, and the inspections will involve applications of the principles developed during the Junior and Senior lecture courses. Moreover, these inspections constitute a direct preparation for the field work in which most graduates of the Department are engaged immediately after leaving the Institute. For the present year the inspections will cover a gasoline risk, a foundry, an automobile factory, a high grade woodworker, a shoe factory, a brewery, and several other manufacturing establishments. Special inspections will cover city fire boats and city department stations containing engines, ladder trucks, and squad wagons, the later constituting the most mobile of fire department apparatus, and being manned by men who measure up to the highest standards in fire fighting.

ARMOUR SOCIETY OF ARCHITECTURE

W.C. Wright	Massier
A. R. Monaco	Treasurer
L. .E. Twery	Secretary
S. C. Hulburt	P. A.

The Architeects have been very fortunate lately in having Mr. Louis H. Sullivan in a series of lectures. As. Mr. Sullivan is well known to be a master in the world of Architecture, we hope he will return at some future date.

The Archs are planning a dance on April 26th, and the Engineers know what that means. They have always had to "hand it" to the boys of the Atelier when it comes to anything in the line of festivities. Those who remember the Mardi Gras of last year will have no doubts on that score. Prepare, therefore, for a good time on that evening. Put it down in your little red book now, before it slips from your mind.

The Juniors and Seniors have finished the Archaeology problems and are now at work on the $250 Home Traveling Scholarship Competition. Enthusiasm runs high this year, as the Juniors are participating in the contest.

THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.
J. J. Schommer Grover Keeth E. G. Hindert

Communications should be addressed to J. J. Schommer,
33rd and Federal Streets, Chicago, Ill.

OFFICERS OF THE ARMOUR ALUMNI ASSOCIATION FOR 1917-18.

Grover Keeth, '06	President
E. C. White, '99	Vice-President
J. J. Schommer	Recording Secretary
J. J. Schommer	Corresponding Secretary
H. L. Nachman, '02	Treasurer
M. L. Flinn, '04	Master of Ceremonies

BOARD OF MANAGERS.

Retiring 1918.	Retiring 1919.	Retiring 1920
E. G. Hindert, '98	T. A. Banning, '07	R. C. Henderson, '02
F. G. Heuchling, '07	H. E. Berkman, '09	B. S. Carr, '15
L. J. Byrne, '04	J. B. Johnson, '12	W. J. Baer, '10

We understand from Mr. Schommer, that nothing worthy of mention has transpired among the alumnus as a gathering, since the last issue of the Armour Engineer. The minutes of the last meeting were published in that issue.

The staff of the Armour Engineer is at present collecting data for a complete Honor Roll of all Armour graduates and past students. The Honor Roll will be published in the Alumnus section of the last issue—the May issue—of this volume.

In order that this list be as complete as possible we would suggest that the reader mail us the names and addresses of all Armour men he knows to be in the service. Ed.

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Herbert W. Puschel
and
Leslie Weiss

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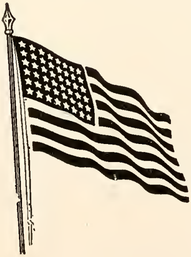

ARMOUR INSTITUTE OF TECHNOLOGY

Honor Roll

MAJORS.

EVANS, P. W.—Commanding Officer, Ice Plant Co. No. 331, Camp Merritt.

TODD, S. B.—81st Division, Field Signal Bn., Camp Jackson, Columbia, S. C.

CAPTAINS.

AGEE, R. E.—3rd Bn., 159th Depot Brigade.

DEAN, W. H.—Co. A., 108th Eng., Camp Logan, Texas.

FRIEDMAN, R. M.—Engineers.

HEMLIN, H.—33rd Division, 108th Eng., Camp Logan, Texas.

HAMMOND, C. H.—Aviation Section, Signal Corps.

HILMES, E. S.—Eng., Fort Leavenworth, Kansas.

LADD, A. L.—Engineers, Officer in charge, Eng. Depot, Newark, N. J.

LUNDGREN, L.—116th Eng., A. E. F., France.

MacEWING, E. D.—Artillery.

MERRILAT, LOUIS—Infantry.

PYNCHON, E. A.—Battery D, 338th Field Art., Camp Dodge, Ia.

REYNOLDS, M. B.—Engineers, Fort Leavenworth, Kansas.

ROSSITER, J. A.—Co. E., 108th Eng., Camp Logan, Texas.

SANNER, C. C.—Co. A., 108th Eng., Camp Logan, Texas.

SMITH, C. U.—Co. E., 2nd Bn., 107th Eng., A. E. F., France.

TAUSSIG, W. S.—Engineers, Camp Grant, Rockford, Ill.

WEART, D. L.—Engineers, Wash., D. C.

WHITE, L. I.—Field Art., Leon Springs, Texas.

FIRST LIEUTENANTS.

ABRAMS, S. N.—Engineers, Phillipines.

ALLPORT, H. H.—Coast Artillery.

ALLYN, A. J.—Engineers, Fort Leavenworth, Kansas.

BAER, W. J.—Ordnance, Rock Island, Ill.

BAILEY, C. C.—303rd Eng., Camp Dix, N. J.

BEAUDRY, R. L.—Field Art.

BLAND, H. W.—A. E. F., France.

BREADY, W. M.—108th Eng., Camp Logan, Texas.

BRETTING, W. H.—Aviation Section, S. O. R. C., Dayton, Ohio.
BURNHAM, C. L.—Artillery.
CLARK, ROLLAND.—Wash., D. C.
COLE, M. C.—331st Field Art., Camp Grant.
EHRLICH, M. W.—149th Art., A. E. F., France.
FRENCH, J. J.—Aviation, Kelly Field No. 2, San Antonio, Texas.
GILBERT, J. J.—Signal Corps, Camp Funston.
GUMPPER, H. D.—Coast Artillery.
HEIM, RICHARD.—Engineers, Fort Leavenworth, Kansas.
HILLOCK, J.—U. S. A.
HAMILTON, C. S.—342nd Machine Gun Bn., Camp Funston.
KILEY, L. D.—Aviation, Foggia, Italy.
KING, K. T.—Ordnance, Springfield, Mass.
MAHER, H. E.—333rd Machine Gun Bn.
MARTIN, H. W.—Ordnance.
MIESSE, R. S.—83rd Field Art.
McGREW, K. A.—Infantry, A. E. F., France.
NEUFELD, R.—Engineers, Camp Dix, Trenton, N. J.
PETERS, R. T.—Infantry, Camp Grant, Ill.
POMERENE, J.—E. R. O. T. C., Camp Lee, Va.
SCHIFFERS, E. A.—Camp Custer, Battle Creek, Mich.
SEXSMITH, H. O.—Army Ambulance Service.
SINCERE, E. M.—107th Eng., A. E. F., France.
DA SILVA, C. J.—Fort Leavenworth, Kansas.
SMITH, S. M.—12th Engineers, A. E. F., France.
STANTON, G. A.—Engineers, A. E. F., France.
WALSH, R. L.—Coast Art., Fort Monroe, Va.
WILSON, L. T.—Field Artillery, France.
WRIGHT, C. F.—Engineers, O. R. C., A. E. F., France.

SECOND LIEUTENANTS.

ADAMSON, J. F.—Engineers, France.
ALLYN, A. J.—Engineers Reserve Corps.
BECHAUD, J. P.—(Deceased).
BOLTE, C. L.—58th Infantry, Camp Greene, Charlotte, N. C.
BOLTON, T. C.—Ordnance.
CLARKE, G. T.—Infantry.
CLARKE, H. G.—83rd Field Art., Palo Alto Field, Calif.

COOBAN, F. G.—Ordnance.
DEAN, C. A.—Engineers, Fort Leavenworth, Kansas.
DOLAN, J. C.—Field Art., France.
DIERSTEIN, F. C.—131st Reg., Houston, Texas.
FARRAR, F. D.—Camp Custer, Battle Creek, Mich.
FARRIER, C. W.—Ordnance.
FITCH, J. E.—Field Art.
FRIES, F. K.—Camp Grant, Ill.
FRYBURG, W. F.—Quartermaster's Corps, N. A.
GEO, D. M.—Coast Art., Ft. Adams, R. I.
GOETZ, O. H.—Quartermasters Corps, France.
GOODSPEED, E. L.—Engineers, France.
GRASSE, C. A.—13th Art., Camp Greene, N. C.
HAMILTON, W. H.—Field Art., Fort McPherson, Ga.
HARVEY, J. D.—Coast Art., Fort Wetherhill, R. I.
HAYES, L. E.—University of Texas, Austin, Texas.
HILL, CLAUDE.—Infantry, Camp Custer, Battle Creek, Mich.
HIBBARD, L. E.—Quartermasters Corps.
INGRAHAM, H. G.—Engineers, Camp Grant, Ill.
KILFOYLE, E. J.—Engineers, N. A., Camp Funston, Kansas.
KNUEPFER, C.—Engineers, Camp Dodge, Ia.
LANG, E. C.—Engineers, Fort Leavenworth, Kansas.
LeVALLEY, J. R.—Ordnance.
LUDER, E. E.—Ordnance.
MAGUIRE, H. B.—Coast Art., Aeroplane Res., Austin, Texas.
McGUIRE, W. P.—Engineers, Fort Sill, Oklahoma.
MARTIN, L. C.—331st Machine Gun Bn., Camp Grant, Ill.
McEWING, L. B.—Artillery.
PHILLIPS, B.—Engineers, Fort Leavenworth, Kansas.
PRATT, T. E.—19th Infantry, Fort Sam Houston, Texas.
RIETZ, E. W.—R. O. T. C., Fort Sheridan, Ill.
ROBERTS, C. H.—Ellington Field, Houston, Texas.
SCHREIBER, E. F.—Aviation Section, Signal Corps, A. E. F., France.
SCHREIBER, J. A.—Aviation Corps, (non-flying).
SHAW, C. L.—E. R. O. T. C., Camp Lee, Va.
SIMMONS, C. R.—Engineers.
SIMPSON, H.—Engineers, A. E. F., France.
SMITH, E H.—Engineers, Camp Custer, Battle Creek, Mich.
SMITH, H. E.—Engineers, Fort Leavenworth, Kansas.

STEWART, J. L.—111th Eng., Camp Bowie, Texas.
STRIDE, H.—20th Eng., Wash., D. C.
SUMMERFIELD, M. L.—Coast Art., Fort Wright, N. Y.
TIERNEY, J. W.—F. O. T. S., Kelly Field, San Antonio, Texas.
WARFEL, L.—Camp Logan, Houston, Texas.

SERGEANTS.

ANNING, H. E.—120th Field Art., Waco, Texas.
BUSBY, F. E.—124th Field Art., Camp Logan, Texas.
FERRENZ, T. J.—E. R. O. T. C., Camp Lee, Va.
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STRESSES IN SHIPS.*

BY SIDNEY V. JAMES, M. E.†

The details of the design and construction of ships have been so long regarded as more or less fixed that interest in the considerations which led to the evolution of such items has necessarily fallen off. In particular, steel ships have been fairly well standardized in their construction by the classification societies such as Lloyd's Register, British Corporation and Bureau Veritas and of late little has been asked of the naval architect in proportioning the sizes and distribution of structural material other than noting the requirements in regard to such features as specified in the rules of such societies.

With the advent of the reinforced concrete ship, however, interest in the stresses to which a ship is subjected becomes of great importance and in order to intelligently distribute the materials entering into the construction of such ships we must have a definite conception of the nature and amount of the stresses to which a ship is subjected under service conditions. Accordingly, it is the purpose of this paper to review the subject so as to present the fundamental considerations involved.

The first part will be devoted to a general statement and discussion of the kinds of stresses, and the second part to a detailed discussion of the methods of determining the principal longitudinal stresses and a brief statement of some of the results of the application of such methods to the study of ships of well-known type. Although these methods are entirely applicable to the design of reinforced concrete ships, it will not be attempted to cover this matter in the present paper. Brief mention will also be made of the question of shearing stresses and of the situation relative to transverse stress calculations.

PART I.

The stresses to which a ship's hull is subjected may be conveniently discussed under three broad divisions: Longitudinal, transverse and local stress. Although these divisions are not entirely separate and distinct they may nevertheless be taken as the three most important phases of the subject.

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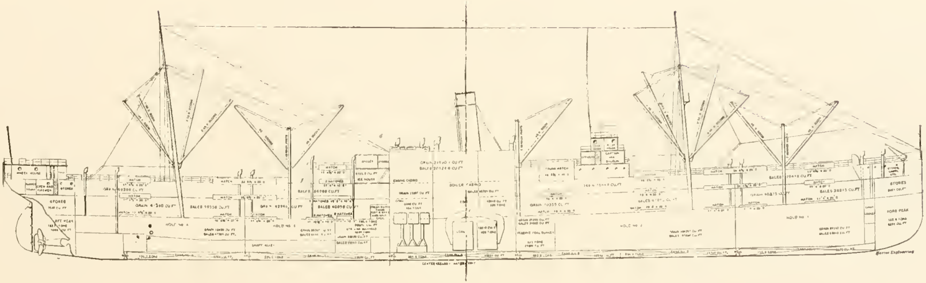
*Address, delivered before Western Society of Engineers, April 6, 1918.

†Class of 1907.


STORES
AFT PEAK
HATCH
GRAIN 6'360 CU FT
BALES 10558 CU FT
HOLD No. 4
HOLD No. 3
SHAFT ALLEY
BALES 66700 CU FT
BALES 60050 CU FT
GALLEY
ICE HOUSE
GRAIN 21930 CU FT
BALES 20129 0 CU FT
ENGINE CASING
BOILER CASING
COAL
GRAIN 10359 CU FT
HOLD No. 2
BALES 20418 CU FT
BALES 38815 CU FT
HOLD No. 1
STORES
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Marine Engineering

Fig. 1.

Longitudinal Stresses.

A ship may be considered as a long boxlike structure supported by and propelled through water. Its underwater portion is pointed towards the fore and aft extremities and is wide and full amidships. Certain interior spaces are devoted to machinery, cargo, fuel, stores, water ballast, etc. As the shape of the underwater portion is determined more by considerations of its resistance to propulsion through the water, than by the fore and aft or longitudinal distribution of the weight of the structure and its contents, there arises a condition whereby fore and aft distribution of the buoyant pressure of the water is not the same as that of the weight. Consequently, there is a tendency for the hull to be deformed by the forces set up due to this inequality. In this connection consider Fig. 1, showing the arrangement of a large freighter. It will be noted that the propelling machinery and boilers are concentrated amidships, the cargo spaces are arranged forward and abaft the machinery and boilers and that the extreme ends of the vessel are utilized as tanks called peak or trim tanks used for carrying water for ballast. In addition to these there are such localized weights as masts, derricks, chains, propellers, etc. When such a weight distribution is considered in relation to the shape of the underwater portion of the hull it will be clear at once that although heavy weights are located amidships where the ves-

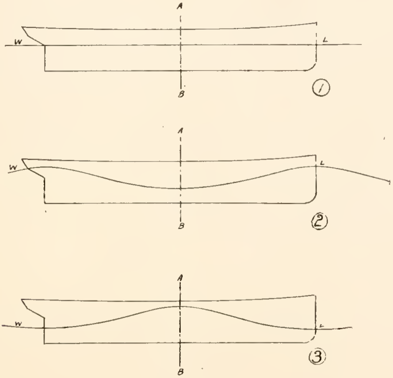

Fig. 2.

sel is widest, many heavy weights are placed near the ends where the buoyant or supporting effect of the water is very small owing to the small displacement of the pointed ends.

It makes considerable difference in the relative distribution of the vertical forces whether a ship is in still or wave water. To illustrate this point Fig. 2 has been prepared to show diagrammatically the *tendency* of waves to seriously alter the distribution of the buoyant effect of the water. The upper of the three diagrams shows a ship in still water, W L denoting the water line. In such a condition the hull is immersed to a practically uniform depth.

In the middle figure the ship is shown resting on a wave as long as the ship, a crest being under each extremity. In this condition the buoyant effect of the water is increased at the ends and decreased at the middle. In this condition a ship would tend to sag in the middle like a beam supported at the ends and centrally loaded. The mid-ship section at A B would probably be the location of the greatest stresses, which in this case would be compression in the upper members such as top sides and upper deck and tension in the lower members such as the lower sides and bottom. Such stresses are commonly spoken of as *sagging* stresses.

The ship shown by the lower diagram has the crest of a wave under its middle portion causing a redistribution of the buoyant support of the water by changing the depth of immersion of the hull at different points. The ends of the ship are relatively unsupported while the middle is submerged to an abnormally great depth resulting in increased support from the water. Consequently the ends will tend to droop downwards; the upper works at the midship section A B will be put in tension and the bottom in compression. Such stresses are spoken of as *hogging* stresses.

The severity of sagging or hogging stresses in any particular case will depend largely on the distribution of the weights. For instance, in the case of a ship having its engines and boilers situated amidships, the sagging stresses will be the greatest when it has its cold bunkers and amidship water ballast tanks filled and a light cargo the bulk of which is concentrated near the middle of the vessel. If under such loading the end or peak tanks were empty and the ship should encounter, head on, heavy seas in which the length of the waves was approximately the sane as that of the ship, the relatively light ends would be well supported when wave crests were under them at the extremities of the vessel. The heavy weights concentrated amidships would augment the sagging effects and the resulting stresses would be high.

On the other hand, imagine the same vessel with cargo holds filled, thus distributing the load well towards the ends of the ship. Towards the end of a long voyage, the coal bunkers may be practically empty and the peak ballast tanks filled. When the crest of a wave equal in length to the ship comes under the midship portion of the vessel, the heavy ends being now relatively unsupported will tend to impose severe hogging stresses in the midship section.

Both sagging and hogging stresses will be somewhat augmented in case the ship is rolling severely while proceeding diagonally across a series of waves and is supported at the extremities or amidships while in an inclined position. Furthermore, the inertia effects of the mass of the ship may not only alter the amounts, but also the location of maximum stresses when the vessel is heaving and pitching in a seaway. The probable effects of such conditions will be mentioned in Part II.

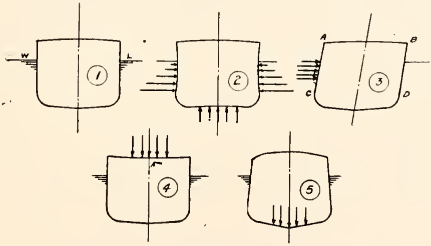

Fig. 3.

The fore and aft unequal distribution of vertical loads which give rise to the sagging and hogging stresses also causes shearing stresses principally in the sides of the vessel. This is readily understood by comparing the ship to a beam supported either at the ends or in the middle and subjected to the vertical forces of the loads and reactions. This will be taken up in further detail in Part II.

Longitudinal stresses are resisted by fore and aft members of the structure such as deck and shell plating, stringers, keel and longitudinal bulkheads.

TRANSVERSE STRESSES.

It is now proposed to consider some of the conditions under which a ship will *tend* to be deformed in a transverse direction. Fig. 3 shows diagrammatically the tendency of each of several well-defined conditions. At No. 1 is shown in outline a transverse midship section of a ship, WL denoting the water line. Obviously the hydrostatic head of the water exerting pressure on the sides and bottom tends to deform the framework as shown by No. 2. The sides tend to bend inward and the bottom upward. The transverse framing must withstand this tendency. In case a ship is rolling or is struck heavily sidewise by a wave, the tendency is somewhat as depicted by No. 3. The angles formed by the deck and the sides at A and B tend to change and the framing at the points C and D where the sides join the bilge also tends to become deformed. A heavy deck load on the weight of a heavy sea shipped on deck will tend to change the transverse form of the ship by bending the deck downwards as indicated at No. 4.

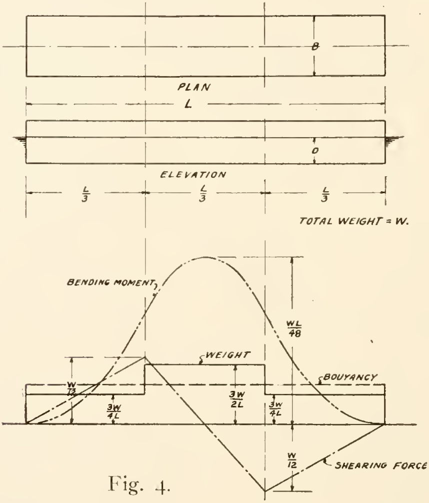

Fig. 4.

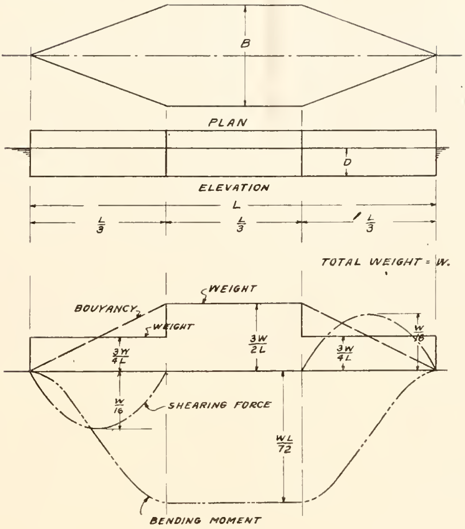

Fig. 5.

Similarly a load due to cargo or concentrated fixed weights such as machinery will tend to change the transverse form as shown by No. 5.

Effects depicted by Fig. 3 are resisted by such structural features as the side plating, frames, deck beams, stanchions (or columns placed between deck beams and bottom), double bottom transverse bulkheads and other details of construction commonly employed in steel ships.

LOCAL STRESSES.

Besides the stresses caused by tendency to change of form transversely, there are many local stresses brought about by the conditions of service such as panting stresses, stresses due to the loading or unloading while aground and launching stresses. Panting stresses are caused by the alternate increase and decrease of wave pressures on the forward end of a vessel while being driven through the water. Such action has a tendency to make the sides work in and out in a manner resembling panting, hence the term. High speed vessels are subjected to more severe panting stresses than slow vessels because of the greater pressure due to the speed. Full or blunt-ended ships present a greater surface to the action of such pressures and hence are likely to experience greater panting stresses than fine-ended ships. The structure is usually specially strengthened to withstand these pressures and so as to minimize deformation and working of the plating.

The propelling machinery imposes stresses on account of the vibration imparted to the entire ship. As every ship has a natural period of vibration it sometimes happens that the vibrations of the engines at certain rates of speed synchronize with the period of the ship and severe stresses may be set up by the resulting excessive vibration of the entire vessel. Additional stiffening and local strengthening of the hull are often necessary to overcome the possibilities of such vibration loosening rivets, opening seams and in other ways producing leakage as well as injury to the structure.

Rudder post stresses are caused by the enormous pressure of the water on the rudder when the vessel is turning. The water pressure is particularly severe in the case of large, heavy, high-speed vessels. The rudder requires careful design not only concerning the post proper, but also the body especially if it be of the type having a central frame with the plating on each side. This sort as to loosen rivets unless proper filling and fastening are employed.

Trading ships are sometimes required to enter tidal rivers and harbors where, when the tide is low, they lie aground. The weight of cargo being loaded or unloaded will, especially if the bottom is uneven, tend to bend and distort the ship's bottom. Cases have been known where bending of the ship has occurred due to the harbor bottom supporting the hull at widely spaced locations.

Closely related to the foregoing is the matter of a ship accidently grounding at high tide and remaining fast with one end supported by the ground and the other by water. It sometimes happens that a ship will ground amidships at high tide. In such cases very severe bending stresses may be set up and ordinarily no attempt is made to allow for such conditions at the time a ship is built.

When the weight of a vessel is being transferred from the launching ways to the water during the ordinary operation of launching, bending stresses are imposed, but they are usually less in magnitude than those imposed by waves in the manner previously discussed. Such moments arise due to the after end of the ship, in launching by the stern, being water-borne while the forward end is still resting on the ways. Sagging stresses are, therefore, caused and unless the ship stops on the ways, no serious consequences follow. If the vessel should stick part way down the ways before the stern is water-borne, large hogging stresses may be set up to the unsupported end overhanging the ways. The bottom may experience local crushing of a serious nature. The cradle supporting a ship has a special supporting member near the bow called the fore poppets. It is at this place that the weight of the forward end of the hull is concentrated at the time the rear end becomes supported by the water and accordingly there is a severe pressure on the hull plating which must be carried by the entire transverse structure.

PART II.

LONGITUDINAL STRESSES.

Having briefly discussed the principal kinds of stresses, it is now proposed to indicate how the longitudinal stresses are determined. As an introduction consider the case of a simple vessel shown in plan and elevation at the top of Fig. 4. This, as you see, is rectangular in plan, elevation and section. For the sake of discussion it has been assumed that the middle third weighs twice as much as either of the end thirds of the length. This assumption is made to roughly approximate the actual ship having engines and boilers amidships. On the base line at the bottom of the figure we have the broken line representing the distribution of the weight. The ordinate of each end portion is $\frac{3W}{4L}$ since each end third of the length equals one-quarter of the total weight and the product of the length of the end portion, $\frac{L}{3}$, and the ordinate $\frac{3W}{4L}$ equals $\frac{W}{4}$. Similarly the ordinate of the middle portion of the weight "curve" is $\frac{3W}{2L}$, since this portion is twice as heavy as each end third.

The line representing the longitudinal distribution of the buoyancy is, of course, at a constant distance from the base line since the draft D is constant throughout the length of the vessel. The ordinate is $\frac{W}{L}$. The difference of the ordinates of the weight and buoyancy "curves" at any point represents the vertical unbalanced force or load acting at that point. Thus throughout the end thirds the buoyancy of the water exceeds the weight and there is a resultant upward force, while throughout the middle third the weight exceeds the buoyancy.

Now by a well-known relationship of the mechanics of beams, the summation of the loads up to any given section from the left end represents the shearing force. This will, as usual, be considered "+" if the part to the left of the section tends to slide upwards and "—" if downwards. Accordingly, summing up the loads beginning at the left end we can draw the shear curve as shown, reaching a maximum of $+\frac{W}{12}$ at the end of the first third of the length. Continuing the process the remainder of the curve is drawn as indicated. The shear becomes zero at the middle of the vessel and $-\frac{W}{12}$ at the end of the middle third of the length.

By another well-known relationship it will be sufficient to integrate the curve of shearing forces up to any given section to obtain the bending moment of that section. Accordingly, the curve of bending moment was obtained by taking the total area under the shearing force curve up to any section. The curve is plotted above the base line since the moment tends to bend the end to the left of the given section in an upward direction. The maximum value of $\frac{WL}{48}$ is reached at the midship section and the ordinate at each end is zero as shown. This vessel is subjected to a sagging moment.

Consider now the case of the hypothetical vessel shown by Fig. 5. In this case the draft is constant at D as before, but the end thirds are pointed. The middle third weighs twice as much as either end third as in the preceding example. The weight "curve" is as before. The buoyancy "curve" rises from zero at the ends to the ordinate $\frac{3W}{2L}$, which is constant throughout the middle third of the length. It will be noted that the loads at the ends exceed the buoyancy hence starting at the left end the shearing force will be minus. Summing up the difference between buoyancy and weight as in the previous case, the shearing force curve is drawn, attaining a value of $-\frac{W}{16}$ at the middle of the left end third, zero throughout the middle third and $+\frac{16}{W}$ at the middle of the right end third. The integration of the shearing force diagram gives the bending moment curve as shown, with a value for this case of $\frac{-WL}{72}$. The minus sign denotes a hogging moment.

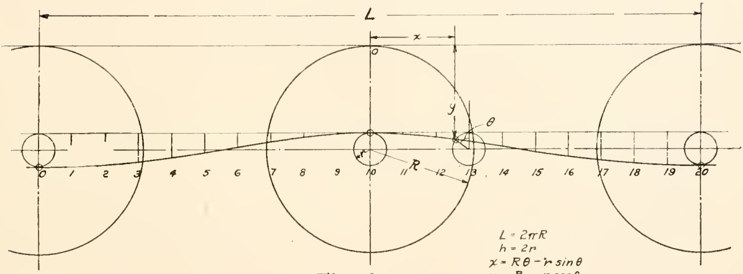

Fig. 6.

Before applying the principles involved in these diagrams to the case of an actual ship, it is well to take up at this point the contour of the wave surface upon which the ship is to be placed as outlined earlier in this paper. It has been found that waves in deep water may be closely approximated by a geometrical form of a wave profile known as a trochoid. Referring to Fig. 6 the large circle with radius R is supposed to roll on the upper horizontal line. A point on the smaller circle with radius r traces a wavelike line as shown. Such a curve is a trochoid and is the typical wave surface used by naval architects in longitudinal strength calculations. The diameter of the tracing circle is taken to represent the height of the wave and the length is, of course, the circumference of the rolling circle, $L = 2 \eta R$ with the origin of coordinates at O, and values of x and y as indicated, the equations representing these coordinates are:

$$x = R\theta - r \sin \theta$$

$$x = R - r \cos \theta$$

The angle θ is the angle through which the large circle has rolled up to the point in question.

As a typical deep sea wave has a height about 1/20 of its length, this proportion is chosen for the wave used in calculation for ships 200 feet or over in length, and the diagram shows a trochoid of this character. In other words L is 20 times the diameter of the small (tracing) circle. For convenience in laying off such a wave quickly the following table may be used in which the value of the ordinate is expressed in terms of the height, $h = 2r$, and is given for each of the stations from 0 to 20 as marked. The ordinate lengths are taken from a horizontal line tangent to the top of the wave. The short lines drawn in on the diagram are the lengths referred to in this table.

TABLE FOR LAYING OFF TROCHOIDAL WAVE HAVING HEIGHT 1/20 OF LENGTH.

Station No....	0	1	2	3	4	5	6	7	8	9	10
Ordinate in Terms of h...	1	.982	.932	.843	.720	.576	.421	.275	.128	.036	0
Station No....	20	19	18	17	16	15	14	13	12	11	10

For use in longitudinal strength calculations such a wave is drawn having a length L equal to that of the ship. Then for the sagging stress calculations the wave contour is laid on the ship drawing with the hollow amidships and adjusted vertically by trial and error (using the ordinary methods of calculating the buoyancy up to the wave line) until the weight of the water displaced is equal to weight of the complete ship under the chosen conditions of loading. In this work it is assumed that the water pressure at any point is strictly proportional to the depth below the surface. The error involved by this assumption will be discussed later.

Similarly for the hogging stress calculations the wave contour is placed with the crest amidships and adjusted until the proper displacement is indicated by the calculations based on the assured conditions of loading.

The vessel is assumed to be head on to the waves and to remain upright in the athwartship direction. Effects introduced by considering the vessel inclined will be considered later. It is further assumed that the waves pass so slowly that dynamic effects such as pitching and heaving may be neglected and the vessel regarded as instantaneously at rest. Consideration of the effects due to pitching and heaving will be taken up after the simpler case has been examined. No account is taken ordinarily, of changes in distribution of buoyancy due to elastic deflection of the vessel.

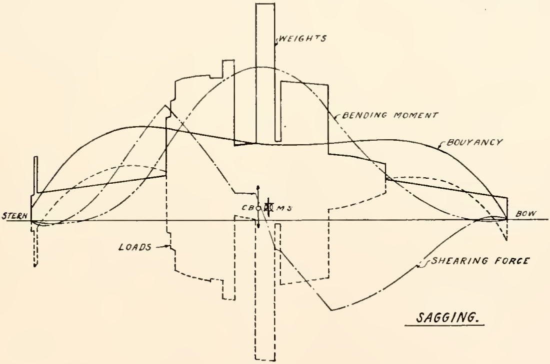

Fig. 7.

In determining the maximum stresses due to sagging it is customary, in case of a merchant ship, to assume the ship to be loaded with as much weight amidships as the most extreme conditions will allow. This usually means that any amidships coal bunkers are filled, any water ballast necessary is assumed to be in amidships tanks and any cargo is to be taken as occupying the hold spaces nearest to the midship portion of the vessel. The end or peak ballast tanks are assumed to be empty. To illustrate the application of such conditions to the case of a typical small merchant ship, consider Fig. 7. The various curves are denoted by wording on the diagram and were obtained in a manner similar to that employed in the simpler cases previously mentioned. The ship in question was 200 feet long between perpendiculars, had a moulded breadth of 31 ft. 10½ in., and a moulded depth (to upper deck) of 22 feet. The maximum bending moment, determined by scaling the original diagram, was found to be 9,700 ft. tons. (The units usually employed in ship calculations involving bending moment; the "long" ton, 2,240 lbs., is meant.)

In determining the maximum stresses due to a hogging moment, the weight distribution is taken as the opposite extreme to that described for sagging. The cargo holds are supposed to be filled and the peak tanks carrying water ballast. Any bottom tanks near the ends are supposed to be filled. The hogging diagram for the ship previously mentioned is shown by Fig. 8. Here the maximum bending moment measured 14,400 ft. tons.

In order to avaluate the stresses to which the extreme top and bottom portions of the structure are subjected, it is necessary to calculate the moment of inertia of the weakest section near the point of maximum bending moment. Methods ordinarily used by engineers for calculating the moment of inertia of the section of any compound girder are applicable here. These will not be discussed further than to say that if certain parts of the structure may not be depended upon to take compression and other parts to take tension, it will be necessary to calculate two values for moment of inertia, one for sagging and the other for hogging stresses. These will have correspondingly different neutral axes.

In the case of the small merchant ship the diagrams for which have just been considered, the moment of inertia for sagging was found to be 7,770,040 in^4., and the distance of the extremities of the strength section from the neutral axis were, top, 169 inches; bottom, 104 inches. Consequently the stresses may be determined by substitution in the usual formula: $f = \frac{M\,e}{I}$, where $f =$ intensity of stress per unit of area,

$M =$ bending moment.
$I =$ moment of inertia.
$e =$ distance from neutral axis to extreme outer fiber.

Applying this to the problem in hand, the compression in the upper deck will be

$$f_c = \frac{9700 \times 12 \times 169}{7,770,040} = 2.54 \text{ tons per sq. in.}$$

or about 5,700 lbs. per sq. in. The tension in the bottom plating at the keel will be

$$f_t = \frac{9700 \times 12 \times 104}{7,700,040} = 1.56 \text{ tons per sq. in.}$$

or about 3500 lbs. per sq. in.

The maximum hogging stress bending moment was found to be 14,400 ft. tons and the moment of inertia, 7,123,000 in.^{4} The values of "e" were 187 in. to top and 86 in. to bottom. Hence, the tension in the deck is

$$f_t = \frac{14,400 \times 12 \times 187}{7,123,000} = 4.53 \text{ tons per sq. in.}$$

or about 10,200 lbs. per sq. in.

Similarly the compression in the bottom is

$$f_c = \frac{14,440 \times 12 \times 86}{7,123,000} = 2.1 \text{ tons per sq. in.}$$

or about 4,700 lbs. per sq. in.

It has been found that the intensity of stress at the point of maximum bending moment may be conveniently determined by the aid of what is known as the intensity factor. This is expressed as follows:

$$F \doteq \frac{WL}{M_{max}}$$

where F is the intensity factor, W the total displacement weight of the vessel in tons (2240 lbs. each), L the length between perpendiculars in feet and $M_{max.}$ the maximum bending moment.

The following table of values, taken from Murray's "Strength of Ships," shows the average values of the intensity factor for different kinds of vessels.

VALUES OF INTENSITY FACTOR

		Hogging	Sagging
War Vessels	Large Battleships	30	50
	Large cruisers	25	30
	Small cruisers	24	25
	Destroyers	20 to 23	17 to 20
Merchant Vessels	Fast Atlantic liners	20 to 25	30 to 35
	Large cargo & passenger	22 to 28	18 to 20
	Small cargo & passenger	30	25
	Large cargo	25 to 30	15 to 25
	Small cargo	25	20

The maximum tensile and compressive stresses to be allowed in practice depend on such conditions as probable usage and estimate life of the vessel, kind of cargo to be carried, materials employed and size of vessel. In speaking of the stresses to be allowed the length of the vessel comes into the problem because, based on the usual or standard assumptions, the wave is taken with a height 1/20 of the length and for extremely long ships such an arbitrary condition would impose higher stresses than those to which the same ship would probably be subjected in actual waves. Such long ships would seldom encounter waves equal in length to the ship and, furthermore, such long waves may have heights less than 1/20 of their lengths.

The approximate stresses to be allowed, based on the standard methods of calculation have been summarized by Murray in "Strength of Ships" as follows:

ALLOWABLE STRESSES.

		Tons per sq. in	Lbs. per sq. in.
Battleship	Tension	7	16,000
	Compression	6	13,500
Destroyer	Tension	9	20,000
	Compression	7	16,000
Large Atlantic Liner	Tension	8-10	18,000 to 22,500
	Compression	6-8	13,500 to 18,000
Cargo and passenger boat (400 to 500 ft.)	Tension	8	18,000
	Compression	6	13,500
Cargo boat (about 300 ft.)	Tension	4.75	10,500
	Compression	3.75	9,000

In the case of a very large passenger or cargo and passenger vessel, stresses as high at 13 tons (29,000 lbs.) per sq. in. have been allowed.

In discussing the assumptions to be made in determining the bending moment it was said that among other things the vessel was taken to remain upright. If the vessel is inclined at the time the extreme sagging or hogging stresses are imposed, the maximum values as obtained by the standard method may be increased anywhere from 10% to 20% depending on the angle of inclination. It will not be attempted to derive the formula which applies in this case but for a point located at a distance x from the longitudinal plane of symmetry of the ship and at a distance y above the neutral axis in the erect position, the intensityof stress may be found by substitution in the following formula:

$$f = M_{max.} \left(\frac{y}{I_x} \cos\theta + \frac{x}{I_y} \sin\theta \right)$$

in which f is the stress per unit of area, $M_{amx.}$ the maximum bending moment, x and y are the coördinates of the point in question (usually the extreme upper corner of the deck at the high side of the midship section), θ is the angle of inclination of the ship, I_x is the moment of inertia of the crosssection about the neutral axis when the ship is erect and I_y the moment of inertia about the vertical axis when the ship is erect. In ordinary calculations I_x is determined and it is only necessary to calculate I_y by a similar method. An application of this formula by Prof. Biles (Trans. Engineers & Shipbuilders of Scotland) has shown a maximum value of "f" about 20% in excess of the "f" for the ship erect when inclined at an angle of 30°.

Another item deferred for consideration was the assumption that the pressure or buoyancy of the water is proportioned to the depth below the surface of the wave. A correction based on a study of the dynamics of trochoidal waves is called for because it can be shown that the water pressure is less than normal at the crest of a wave and greater than normal at the trough of a wave. Accordingly, the increased buoyancy due to crests will be actually less than that shown by the standard calculations and the decreased buoyancy of a wave hollow will be less than the standard Both these effects will diminish somewhat the bending moments. Hence the standard calculations give a basis on the safe side. The reduction in the moments has been found to vary from 5% in the case of small vessels to 12% for large vessels.

There are two other effects spoken of previously which alter the maximum bending moment. These are heaving and pitching.

Heaving is vertical oscillation of a ship and pitching is the oscillation about the transverse gravity axis. In heaving a ship sinks and rises vertically and in pitching it dips and rises alternately at the bow and stern. Heaving has been investigated and it has been found that, due to the inertia of the entire mass of the ship the maximum bending moment in waves of standard proportions may be increased about 10% for relatively long ships.

Pitching has a tendency to increase the bending moment between the point of maximum determined by standard conditions and the ends of the ship. It may in some cases bring the bending moment at points about ⅓ of the length from the ends of the vessel to a value equal to the maximum near the midship section. This effect and the consideration of shearing stresses, to be discussed in the next paragraph, generally warrant increased strength at the regions of the ship at a distance from ¼ to ⅓ of the length from each end.

To take up the question of shearing stresses it will be noted by reference back to Figs. 7 and 8 that the greatest vertical shearing forces occurred at about 1/4 of the length from either end of the vessel. The cross-section at this region should, therefore, be investigated to make sure that the intensity of stress per unit of area due to shearing will be within safe limits. It can be shown that the intensity of shearing stress varies considerably throughout the section of any girder or beam and that it reaches a maximum at the neutral axis. The formula for the intensity at the neutral axis is to be found derived in any standard work on mechanics and reads as follows:

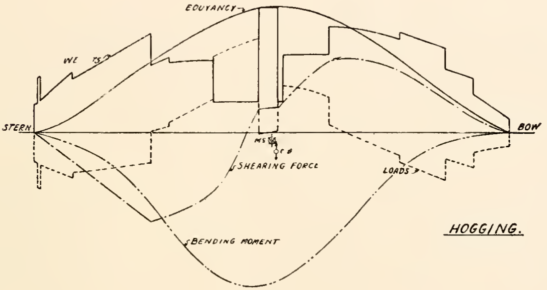

Fig. 8.

$$s = \frac{V}{It} Ay$$

where s is the shearing stress per unit of area, V is the vertical shearing force at the section in question, I is the moment of inertia of the section, t is the width of the section at the neutral axis, A is the area of the section on one side of the neutral axis, and y is the distance from the neutral axis to the center of gravity of the area A. In other words, Ay represents the statical moment of the area on one side of the neutral axis and this is already available from the detailed computations required to obtain the moment of inertia.

It may be of interest to see what result is obtained by applying this to the case of the small cargo steamer for which the logging diagram was calculated and shown as Fig. 8. The maximum shearing force in this case was 274 tons, the whole sectional area at the section of maximum shearing force was 788 sq. in. The statical moment Ay, of the formula, figured out to be 36,264 in.^{3} The moment of inertia was 7,599,152 in.^{4} and the combined thickness of shell plating was 2 × .44 or .88 in.

Hence the maximum shearing stress was found to be

$$s = \frac{274 \times 36{,}264}{.88 \times 7{,}599{,}152} = 1.48 \text{ tons per sq. in.}$$

or approximately 3,330 lbs. per sq. in. This, it will be observed, is considerably larger than the average shearing stress figured for the entire section as follows: $\frac{274}{788} = .35$ tons per sq. in. or about 785 lbs. per sq. in. Further considerations are usually involved such as investigation of the intensity of shearing stresses in the rivets of the shell plating seams and it may be necessary in some instances to increase the riveting at the neighborhood of maximum shear from double to treble riveting.

We have discussed the question of longitudinal stresses and the shearing stresses due to longitudinal loading. Such stresses may be somewhat readily approxmated as we have seen, but no simple method readily applicable has as yet been discovered whereby transverse stresses may be determined. On this account steel ships have been designed on an empirical basis established by the classification societies and fully covered by their rules. Compliance with such requirements or their equivalents is necessary in order to obtain insurance on the finished vessel. Such a procedure is ordinarily quite satisfactory when designing a steel ship, but with the substitution of other materials such as reinforced concrete, it becomes of interest to know how to distribute the concrete and reinforcing steel so as to provide adequate transverse strength. The most practicable method now available, it seems to the writer, is to design the transverse members so they will be equivalent in strength to the steel members which would be required for a ship of the same size and character. Such calculations could be based on some arbitrarily assumed conditions of loading and should be sufficiently exact for this purpose.

Attempts have been made in the past to investigate the transverse strength of a ship by an application of the principle of least work and reference may be made to an historic paper on this subject by J. Bruhn, published in the "Transactions of the Institution of Naval Architects," 1901. The method there indicated has been extended and applied by A. J. Murray in his "Strength of Ships." The conditions assumed in such calculations involved the depth of water, i. e., the water pressure on the hull, and the stiffness of the framing members. The numerical work required is long and tedious and owing to the unknown effects of rolling and pounding of the ship in a heavy sea, not to mention the possible shifting of cargo incident thereto, it does not appear to be profitable to carry out such computations. In certain cases they may be of value as far as determining relative strength of different structures is concerned.

It is hoped that the foregoing remarks have placed before you the main features to be considered when the stresses in ships are to be determined. It is also hoped that those who are interested in the future possibilities of ships constructed of material other than those well-tried in ship service will have been brought to realize the peculiar problems involved. Much has been said and written recently about the use of reinforced concrete as a substitute for steel construction and we are all vitally interested in such possibilities especially at this time when the problem of building many ships quickly has been complicated by shortage of labor and materials. The substitution of concrete for steel should be thought out carefully and conservatively, bearing in mind the peculiar stresses to which a ship must be subjected.

THE REPUBLIC.

From "The Building of the Ship."

Thou, too, sail on, O Ship of State!
Sail on, O Union, strong and great!
Humanity with all its fears,
With all the hopes of future years,
Is hanging breathless on thy fate!
We know what Master laid thy keel,
What Workmen wrought thy ribs of steel,
Who made each mast, and sail, and rope,
What anvils rang, what hammers beat,
In what a forge and what a heat
Were shaped the anchors of thy hope!
Fear not each sudden sound and shock,
'Tis of the wave and not the rock;
'Tis but the flapping of the sail,
And not a rent made by the gale!
In spite of false lights on the shore,
Sail on, nor fear to breast the sea!
Our hearts, our hopes, are all with thee,
Our hearts, our hopes, our prayers, our tears,
Our faith triumphant o'er our fears,
Are all with thee—are all with thee!

—LONGFELLOW.

A COMPREHENSIVE METHOD OF TESTING VARIABLE-SPEED VARIABLE-LOAD GASOLINE ENGINES.

BY DANIEL ROESCH*

The present method of testing gasoline engines for fuel consumption is adequate for some types but appears inadequate for others. The results obtained by the conventional method of testing the latter are meager and apparently fail to comprehensively represent either the actual or the comparative fuel consumption of the engines tested. In order to improve this condition a method of testing engines of this class has been developed during the past four years in the Gas Engineering Laboratories of the Armour Institute of Technology. This brief outline will serve to bring out the more important phases investigated and the conclusions derived.

The fuel consumption or efficiency tests of gasoline engines are conducted to show this characteristic within their range of operation. The engines can be divided therefore, into three classes as follows:

Tests of engines operating:

(1) At constant speed and variable load.
(2) At constant load and variable speed.
(3) At variable speed and load.

Class (1) represents engines of the governed stationary type such as are used for central stations, power houses, and on the farm. Their speed while operating normally is approximately constant.

Class (2) are not represented in commercial use, although pumping engines approach this type.

Class (3) represents engines of the automobile, motorcycle, marine, and aeroplane types. These engines in normal operation are subjected to wide ranges of speed and load. All commercial engines are included in classes (1) and (3).

Conventional Tests: *Class* (1) *Engines*:

The conventional efficiency tests of an engine of Class 1 is usually graphically represented by the fuel consumption on the ordinates and the power developed on the abscissa. The method of representing the fuel consumption may be

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*Class of 1904.

(a) Total fuel per hour (Weight or Volume)
(b) Total fuel per hour (B. t. u.)
(c) Fuel per B. h. p., per hour (Weight or Volume)
(d) Fuel per B. h. p., per hour (B. t. u.)
(e) Thermal efficiency (Per Cent)

Curves (a) and (b) will be similar but to different ordinate scales; this also holds true of curves (c), (d), and (e).

For comparison of engines using fuels of equal heating values, the curves (a) and (c) are usually sufficient. When comparing tests of engines using fuels of different heating values the use of curves (b), (d), and (e) becomes necessary.

Curves of this kind show the complete efficiency performance of the engine within its operating conditions and would appear adequate for recording actual or comparative performance.

Class (3) *Engines*:

The conventional tests of class (3) engines have usually been made with with open throttle and more recently at some more or less fixed partial load. It is to be clearly noted that fuel consumption tests of this nature involve the representation of three variables, namely,

(1) Speed of engine.
(2) Load on engine.
(3) Fuel consumption.

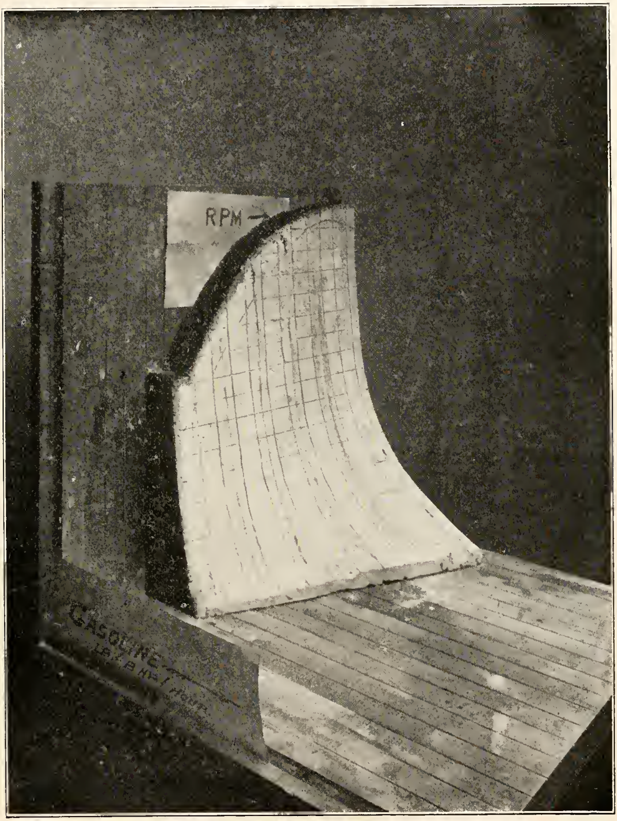
There are at least two clear methods of representing the relationship of three variables; First, by the use of a surface, i. e., the three dimensions to the reference planes represent to scale the value of each of the three variables. Second, by the use of contour lines on a plane surface. Each contour line can then represent a specific value for one of the variables and the coordinates the values of the other lines.

The above two methods of showing the relations between three variables have been widely used along other lines.

The first method is represented in thermodynamics where it is desired to show the relationship between Pressure, Volume and Temperature.

The second method is used in the weather bureau reports where lines of equal barometric pressure are graphically represented.

It would appear therefore, that to clearly and comprehensively represent the fuel consumption of a variable load, variable speed engine it would be necessary to derive data of such nature as to permit its being represented by a surface or a set of contour lines.



Gasoline Consumption for all Loads and Speeds.

The data taken during the development tests mentioned have met this requirement and the results produced have been found to be peculiarly interesting and valuable in point of conciseness and completeness, both from an academic and practical point of view.

Method of Taking Data.

In general we have at least six variables in an engine of the class (3) type, namely:

(1) Speed.
(2) Torque.
(3) Horse Power.
(4) Fuel consumption.
(5) Intake manifold depression.
(6) Throttle position.

The horsepower is a function of the torque and speed and the relationship can be easily established for any particular condition by a formula.

The fuel consumption, intake manifold depression, and throttle positions are a function of the horsepower and speed but no formula will ever be applicable since the engine and carburetor characteristics also influence these characteristics.

The desired relationship is that of items Nos. 1, 3 and 4. The means of obtaining the data required has been investigated along the following lines:

(1) If for various constant speeds the fuel consumption is determined for different horsepowers within the range of operation, the results will show the complete operation of the engine. Interpolation for intermediate speeds of course becomes necessary.

This means of obtaining this data would be very desirable were it not for the practical limitations of holding the engine at a constant speed under varying loads. The incorporation of an extremely sensitive throttle governor to hold the engine at 200—300—400—500, etc. r. p. m. would make this a convenient and desirable method of taking data.

(2) If for various constant torques the fuel consumption is determined for different speeds within the range of operation, the results will give the complete fuel consumption characteristics of the engine. Interpolation (preferably on charts) again becomes necessary for intermediate torques. This method of taking and representing data is described in the S. A. E. Transactions, Volume 12, Part 1, Page 338.

(3) The maintaining of various constant horsepower outputs and determination of fuel consumption for various speeds involves complications that are not readily overcome.

(4) Maintenance of various constant fuel consumptions and the determination of the speed and horsepower again involve serious complications.

(5) The maintenance of a constant manifold depression offers a convenient and comprehensive means of obtaining the test data required. Here we have immediately a choice of operating the engine at a manifold depression of say, 3-6-9-12-15, and 18 inches of mercury or at absolute manifold pressures of say, 27-24-21-18-15, and 12 inches of mercury. The latter method seems preferable inasmuch as tests made at different barometric pressures will in a measure at least automatically compensate for variations of barometric pressure. Data taken by this method is replotted in (a) constant r. p. m. data, (b) constant fuel consumption lines. The latter will be contour lines of equal thermal efficiency and provide the necessary data to establish the surface representing the three variables, i. e., speed, horsepower and fuel consumption.

(6) If for various constant throttle openings the fuel consumption is determined for different speeds and resultant horsepower, the desired data can be obtained. The method has the objection that the horespower varies widely with the speed for a fixed throttle. This results in an unequal distribution of the first curves obtained. Interpolation of data becomes less certain and final results not as reliable.

The results of a rather complete study of the subject indicate preference to methods Nos. 5, 2, 1, and 6, in the order named. Method No. 5 permits also of determination of lines of equal mechanical efficiency by the electric dynamometer method. The exact determination of this factor by any of the other methods is at present not apparent. The mixture ratio is another valuable characteristic that can be simply and comprehensively shown by the method above recommended. In such a case comparative carburetor performance can most clearly be presented in a complete manner. The ideal surface in this work would be a flat surface showing the ideal mixture ratio at all speeds and loads.

The accompanying cut shows a view of a plaster cast mounted on reference surfaces and shows a complete gasoline consumption characteristic for all loads and speeds.

RAILWAY SIGNALING

BY J. E. SAUNDERS

Asst. Chief Engineer, Union Switch & Signal Co.

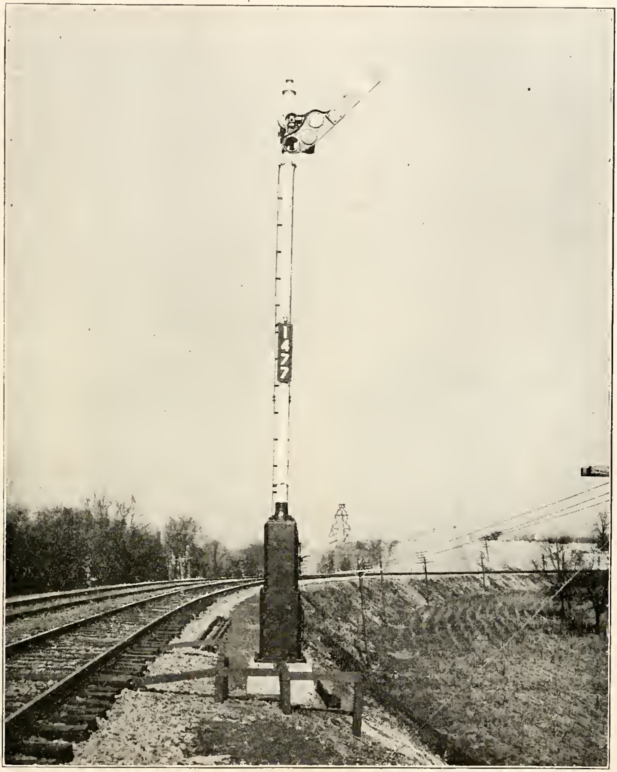
Railway signaling may be defined as a means of controlling the movement of trains. In its narrow sense, the word "signal" comes from the Latin "signum," meaning "a sign, some concrete thing which by its position, color or wording conveys information." The wider scope of railway signaling is indicated in the derivation of the word "semaphore," which comes from the Greek "sema-phora," meaning "to carry a sign." Signaling, then, is a means of conveying information from the person directing train movements to the person operating the train.

Before spoken language was made use of, information was conveyed by means of signs. The semaphore was first used for military purposes in France in 1700 and in Russia during the reign of Nicholas I. The first railway signaling, concerning which we have any information, was used in England in 1841, although track switches were operated by means of levers as early as 1840. The first interlocking of levers operating switches was installed to secure greater economy of man power, in England. It is interesting to note that the first interlocking installed in the United States was with the idea of increasing the safey in handling traffic.

The purpose of railway signaling is two-fold; first, to increase safety in handling of railway traffic, and, second, to expedite this traffic.

There are three divisions of railway signaling—train order, block and interlocking. Train order signals may be either mechanical or electrical, and are used as a means of conveying information from the station operator, or leverman, to the engineman in charge of a train, indicating whether any train orders are held for the train in question. Train order signals ordinarily indicate stop or proceed, although some of these indicate in three positions. Electric train order signals are used only where the distance from the operating point is too great to allow for their satisfactory operation mechanically.

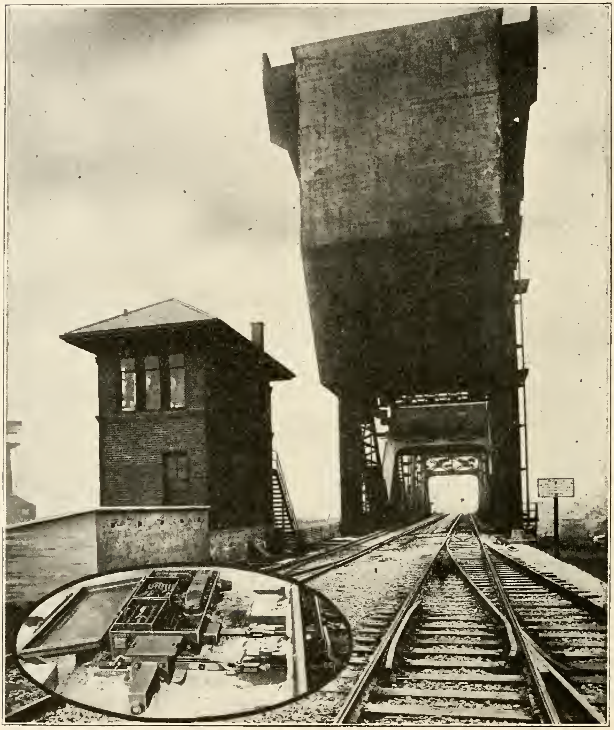
There are three classes of block signals—manual, controlled manual and automatic. Manual block signals are ordinarily operated solely by levers under the control of the operator or leverman at a signal station. The signal governing train entrance to a block, or track extending from one station to the next, is not to be cleared, except when this section of the track is known to be unoccupied. Telephone or telegraph communication between adjacent block offices or stations is essential to the satisfactory handling of the manual block system.



Style S, Electric Signal at an Electro-Mechanical Interlocking Plant.

The controlled manual block has, in addition to the parts required for the manual block, electrical interlocking between adjacent stations, which insures the co-operation of the levermen before a signal can be cleared for train entrance into a given block. This electrical control may also include complete track circuit protection between stations.

Automatic block signals require the use of power-operated mechanisms or light signals. Electricity is ordinarily made use of for the control and operation of signals of this type, and the track circuit is considered essential to their satisfactory performance. Automatic signals may be installed in conjunction with various forms of manual block and interlocking without serious interference with the workings of any of these systems.



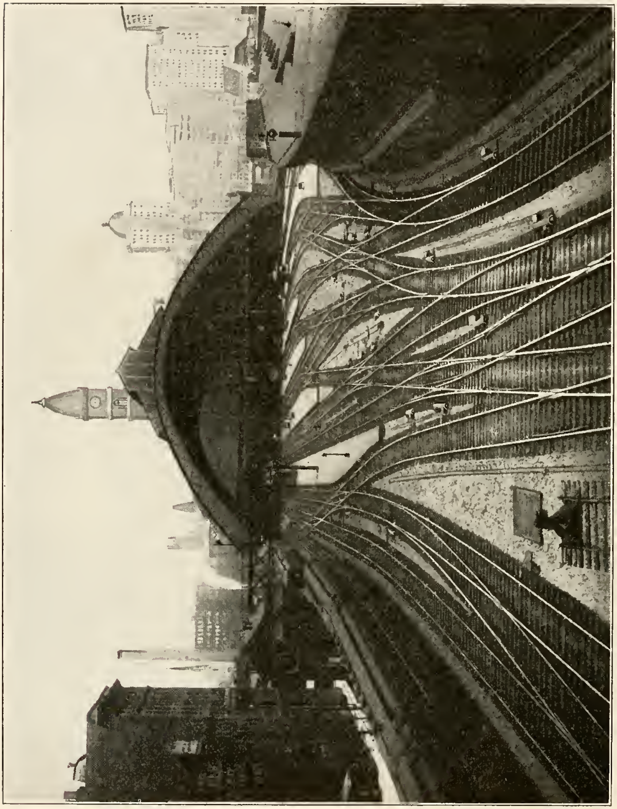
Type F, Electric-Interlocking System.

The term "interlocking," as applied to railway signaling, means an arrangement of controlling and operating devices, by means of which track switches and signals may be operated for the safe handling of trains where there are track intersections, or where a sufficient number of switches are so located as to warrant their centralized control. The term "interlocking" has particular reference to the mechanical connections of levers used for operating the switches and signals, which is such that the movement of these must occur in given sequence. There are four types of interlocking, mechanical, electro-mechanical, electric and electro-pneumatic. No one of these types can be considered as best of all layouts and operating conditions. The type of plant to be installed is determined, first, by the number of units to be controlled; second, by their relative locations; and, third, by the cost of upkeep and maintenance, power, labor, etc.

Mechanical interlocking is that in which the levers in the tower are connected to the switch points, detector bars, locks and signals by means of pipe lines, 1″ heavy iron pipe being used. Some of the signals may be operated by means of mechanical wire lines, No. 9 steel wire being used. Mechanical interlockings are confined to plants requiring but few levers and in which no switches or signals are located at any very great distance from the central point or tower. Maintenance and renewal charges for this type of plant are great.

Electro-mechanical interlocking is that in which the switches are operated by means of pipe lines connecting the levers with the points, while the electric locking and signals are arranged for electrical control and operation. This type of plant has particular application to small size interlockings at track intersections and junction points where automatic signals are in use and it is desired to continue these through the interlocking. There is no limit as to the distance signals can be located from the tower, but the same limitations hold with respect to switches operated therefrom, as in the case of the purely mechanical plants. The more complete schemes of automatic protection, such as approach route and section locking, may be applied for the protection of traffic in electro-mechanical interlocking.

Electric interlocking may be installed for plants of any size and is used quite generally for interlockings where the number of switches and signals is too great for the satisfactory use of electro-mechanical machines. Both switches and signals are operated by means of electric motors controlled from the central point or tower. Electric plants have been installed where either direct or alternating current have been supplied. Wherever direct current is made use of, a storage battery is a requisite.



Electric-Pneumatic Interlocking System.

Electro-pneumatic interlocking has been installed more generally where traffic was heavy and where considerable economy could be effected by the introduction of compressed air for the operation of switches and signals while these are still controlled electrically. Over 90% of the railway terminals in the United States have interlockings of the electro-pneumatic type. The more recent developments in devices used in this type of interlocking, with a resultant saving in air consumption, make it appear probable that the field of electro-pneumatic interlocking will be extended quite generally to cover many of the smaller isolated plants where electricity alone has formerly been in use.

The automatic protection and interocking of electric railway lines is becoming more common, as these are assuming greater prominence in the traffic field. Most of the heavier interurban lines are already protected and the electric railways, like the Interboro in New York, which operate at maximum track capacity, have found in complete signaling systems not only a safeguard for human life but also a means of greatly increasing the number of trains which can be operated on a given section of track in a given period of time.

Since railway signaling enters so vitally into the question of track capacity and the expeditious handling of traffic through yards and busy terminals, it is quite probable that installations of both automatic signals and interlockings will be made even more generally in the future than in the past, notwithstanding the fact that installations have already increased to a very great extent during the last few years. With the more general introduction of railway signaling, this field has become more attractive for graduate engineers. Most of our technical schools are now represented in the various railway and manufacturing organizations handling this kind of work.

A GENERAL DESCRIPTION OF THE APPARATUS OF THE POWER PLANT EMPLOYED IN MODERN TELEPHONE PRACTICE

BY E. H. ARNOLD.*

The methods of supplying current to the transmitter of a telephone may be classified into two divisions. First, those in which the source of energy is located at the substation, or instrument itself; and second, those in which the battery or other source of current is located at a point distant from the transmitter. In general, both methods of energy supply have their favorable and unfavorable characteristics, depending largely upon the circumstances under which they are used.

Due to limitations set by heating, only a small current may be permitted to pass thru the transmitter. If the transmitter is placed directly in the line circuit, it is evident that since its resistance changes only a small amount in responce to varying pressures on the diaphram, the relative change with respect to the line resistance is small. Yet this is the condition experienced in common battery practice, largely relieved however by auxilliary apparatus in the instrument circuit. The local battery system places the transmitter in a circuit with a source of current and the primary winding of an induction coal. Thus relatively greater changes of current value are obtained without an excess of heating.

This great advantage in transmission is attended however by certain limitations in its use from a commercial standpoint. While it is true that a primary battery is not an economic way to generate energy, this disadvantage would not in itself be of great importance. The more serious objection is from the standpoint of maintenance; that is the renewals which involve loss of time in travel from station to station, to say nothing of the cost of material. At present time then, local battery systems are confined to small communities where uninterrupted service is not an economic necessity.

With the growth of the business came a demand for a more economical means of energy supply, and furthermore large users demanded more compact apparatus than could be built to include such local equipment. The result has been the concentration of all sources of energy at the Central Office. The central battery stands ready to send current over a line whenever the subscriber raises his receiver; this system then adapts itself to the purpose of automatic signalling, not only to the line apparatus, but also to the cord supervision as well.

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*Class of 1919.

The discussion which is to follow will treat briefly of the power plant which constitutes the electric energy supply of this centralized system.

General Description of Power Plants

The telephone power plant is an organization of energy converting and controlling devices, to furnish to a telephone system the several kinds of current, at proper pressures, for the performance of the general electrical tasks of the exchange. The several kinds of current required are; direct current for transmitters, relays, line and supervisory signals, busy tests, collection of coins, operation of message registers, and in many small exchanges in the form of pulsating current for ringing biased bells. Alternating current is used for ringing bells and for signals over composite lines.

In its elementary form, a telephone system consists of two instruments, one at each end of a line, the power plant consisting of a hand generator to ring the call bells, and a set of dry cells to supply a current to the transmitter. In such a system each telephone has its own power plant. However, when a number of telephones are connected to a common meeting place known as the exchange, all or part of the power plant is also located in this central position. The requirements for current supply differ greatly for magneto and common battery systems.

In the case of magneto systems, the current for throwing the line drop on the board is supplied by the station hand generator, and the current for the station transmitter is supplied by a set of cells at the station. Thus the central office supplies only such current as is needed by the operator to talk to the station, and to ring and supervise the line. When multiple boards are used, current is also needed for busy test, and in some installations for restoring drops electrically.

In the common battery system, the substation has absolutely no source of current of its own, but depends entirely upon the central office. A common source of direct current is supplied for talking and operating line signals and supervisory apparatus. There is also a source of alternating and pulsating current for ringing bells and operating special signals.

Direct Current Supply

Storage Battery:

Direct current for transmitters and relays is ordinarily supplied by a common storage battery; which having low internal resistance may be used as a supply for an indefinite number of lines without causing cross-talk. That is, the variation of consumption in one circuit leading from it causes but slight variation in consumption in other circuits leading from it. In furnishing common battery it is also necessary that there be low resistance and inductance in the conductors leading from the battery which form part of all the circuits concerned. Hence such leads are large in cross section and as short as possible.

The specialized low voltage direct current used to keep the storage battery charged is usually obtained from a motor-generator set or a mercury-arc rectifier; these being operated from the commercial power mains. In some cases where direct current is available, resistance is merely placed in series with the exchange battery; it is better practice however, to use some kind of translating device.

All storage batteries in extensive use in telephone systems today are of the well known lead and sulphuric acid type. The containers are usually glass for the smaller cells, while wood and lead construction are used for larger units. The capacity of the cell is of course determined by the size and number of plates, while the desired potential is obtained by connecting the necessary number in series. Most city exchanges operate on a voltage of twenty-four, and to obtain this as an average use eleven cells in series. Storage cells used in this work vary from 2 plates having an area of 12 s. in. to cells having 50 plates and an area of 240 sq. in.

In installing glass jar cells it is common practice to place them in trays containing sand, but they are often mounted on insulaters which prevent leakage by moisture. Wooden tanks are placed on glass insulators, with enough clearance between the tanks to prevent shorting of the linings. When the plates have been installed, their lugs are connected to the bus bars either by lead covered clamps, or in the larger types by lead burning. When the tanks have been filled with electrolyte of specific gravity 1.180 to 1.190 to within ½ inch of the tops of the plates, the charge is started at normal rate. Readings are taken hourly of the specific gravity and temperature of the electrolyte, the voltage of the cells and the charging current. The initial charge is continued 10 hours after the voltage and specific gravity have reached their maximum. The temperature readings are used to correct the specific gravity as determined by the hydrometer. This correction is usually made by adding .001 s. g. for each 3 degrees in temperature above 70 degrees, or subtracting the same amount for each 3 degrees below 70.

The specific gravity of a battery will vary the same in all cells when once properly adjusted, and hence it is satisfactory to use one cell, known as the pilot cell, for taking specific gravity readings; the individual readings being made only on overcharge.

Battery Charging Generator:

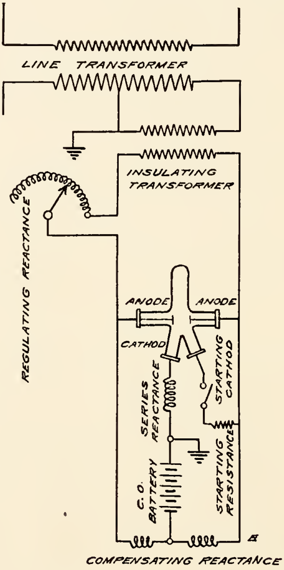
Motor-generator sets are most used for charging the office battery. The motor being designed for the commercial current available, and the generator for the local demands of the exchange. The generator is designed to develope a voltage slightly above that of the storage battery when at its maximum charge, so as always to be able to deliver current to the battery.

An important feature is the smoothness of the generator; if the generated current were absolutely smooth, its leads could be connected directly to the bus bars of the office, and the storage battery used merely as a reserve source of energy. However, the ability to carry the office load directly on the generator is of no importance except in cases of battery failure. Special noiseless telephone generators are now made which deliver such smooth quality of current that they may be used to charge the batteries while the latter are supplying the power board, or to supply the talking current direct in case of total failure of the batteries. Where there is a slight interference due to noticible pulsations in the generated current, an impedence of low resistance is inserted in the charging circuit.

Mercury-Arc Rectifier:

In smaller offices where the commercial supply of energy is alternating current, a mercury-art rectifier is often used to transform to direct current. This apparatus is of high efficiency and produces no noise. The circuit of such an arrangement is shown in fig. 1.

"The mercury-arc rectifier proper consists of a glass bulb containing vacuum and a small amount of mercury. When its terminals are connected as indicated—the two anodes across an alternating current source and the cathode with a circuit that is to be supplied with direct current—this device has the peculiarity of action that current will flow alternately from the two anodes to the cathode and never from it. The cathode, therefore, becomes a source of positive potential, and, as such is used in charging the storage battery thru the series reactance coil and the compensating reactances, as indicated. The line transformer shown at the upper portion of the sketch is the one for converting the high-potential alternating current to the comparatively low-potential current required for the action of the rectifier. The transformer below this has a one to one ratio, and is called the insulating transformer. Its purpose is to safeguard the telephone apparatus and circuits against abnormal potentials



MERCURY ARC RECTIFIER
CHARGING CIRCUIT
Fig. 1.

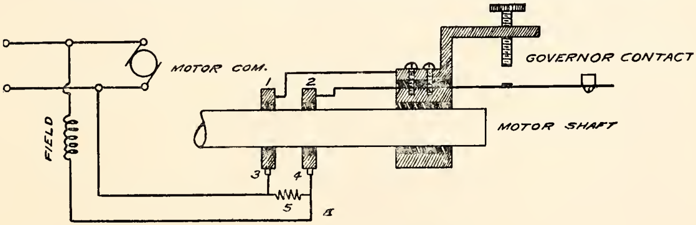
from the line, and also to prevent the ground, which is commonly placed on the neutral wire of transformers on commercial lighting circuits, from interfering with the ground that is commonly placed on the positive pole of the Central Office Battery."*

Alternating Current Supply

Alternating currents for ringing are largely furnished by alternating current dynamos, properly designed for the frequency and voltage desired. Only very small exchanges find hand operated magneto generators sufficient for their needs, and in most central offices therefore, a generator driven by some source of power is found. Many exchanges of medium size use a pole changer operated by dry cells, for ringing.

Ringing Generators:

For a number of years after the common battery system came into use, the subscribers on a party line were signaled by code ringing. The next step was selective ringing by using in connection the usual low-frequency alternating current, certain pulsating currents which operated bells specially designed to respond only to certain portions of the pulsating cycle. A split ring is mounted in the shell with the alternating collector rings. This third ring is connected to the windings in such a way that the positive and negative sets of pulsating waves may be drawn off and used independently of each other.



MOTOR SPEED GOVERNOR

Fig. 2.

Such generators being either direct or belt driven by a motor, and since the frequency must remain practically uniform, a constant speed of the motor is essential. Such a condition is obtained by the use of a governor attached to the motor shaft and controlling the shunt field of the motor. The operation of such a governor, as shown in fig. 2, is as follows.

"A weighted spring acts, by centrifugal force, to make a contact against an adjustable screw, when the speed of the shaft rises a predetermined amount. This spring and its contact are connected to two collector rings 1 and 2 on the motor shaft, and connection is made with these by the brushes 3 and 4. The closing of the governor contact serves therefore merely to short circuit the resistance 5, which is normally included in the shunt field of the motor. This governor is based on the principle that weakening the field increases the speed. It acts to insert the resistance in series with the field winding when the speed falls, and this in turn, results in restoring the speed to normal."*

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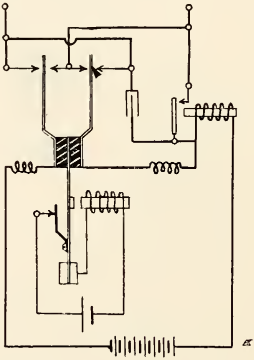
*Telephony, McMeen and Miller.

Pole Changers:

In many ring-down exchanges located where commercial energy is not available, pole changers are used to supply the pulsating ringing current. One of the most common types of pole changers is the Warner, the circuit of which is shown in fig. 3.



WARNER POLE CHANGER
Fig. 3.

"In this, an electromagnet is supplied by a constant current battery to keep the vibratory system in motion. The motor magnet and its battery work in a local circuit and cause vibration of the armature. The battery from which the ringing current is derived is as shown, and the poles of this are connected to the vibrating contacts. These contacts are merely the moving members of a pole changing switch, and a study of the action will readily show that when these moving parts engage the right hand contacts, current will flow to the line supposed to be connected to the terminals, in one direction, while when those parts engage the left hand contacts, current will flow to the line in the reversed direction. The circuit of the condenser shown is controlled by the armature of the relay. The winding of this relay is put directly in the circuit of the main battery so that whenever current is drawn from this battery to ring a distant bell, this relay will be operated and will bridge the condenser across the circuit of the line. The purpose of the condenser is to make the impulses flowing from the pole changer less abrupt, and the reason for having its bridged circuit normally broken is to prevent waste of current from the battery, due to the energy which would otherwise be consumed by the condenser if it were left permanently across the line."*

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*Telephony, McMeen and Miller.

An interesting piece of apparatus, designed to take the place of battery operated pole changers where continuous alternating current is available, is brought out by the Leich Electric Co. As shown in fig. 4, it operates from 60 cycle, 110 volt commercial circuits, and delivers a ringing current at 90 or 110 volts of 20 cycles. The transformation is accomplished by means of rectifying vibrators which change the alternating to direct current, which is then changed back to alternating current at 20 cycles. The voltage is raised to 90 or 110 by means of transformers. Positive and negative pulsating current for selective 4-party ringing may also be obtained. It is claimed that the normal current consumption of this converter is but 10 watts per hour.

The circuit of this equipment is shown on the next page. The two watt tungston lamp is used for protection against short circuiting the converter when ringing over a short-circuited line. The post marked G is the ground connection; between G and L, 90 volts may be taken, and between G and H, 110 volts. The two vibrators A and B are the rectifiers, and are connected across the line, producing direct current by the aid of an impedence coil C. The pole changer D is mounted directly under these; it acts with the transformer E to produce the required ringing current. The frequency may be varied by changing the position of the weight "w" on the armature. If positive and negative pulsating current is desired in addition to the 20 cycle current, a converter is furnished which is equipped with an additional set of contact springs. These contacts deliver the positive and negative pulsations from the secondary of the transformer to their respective terminals so marked.

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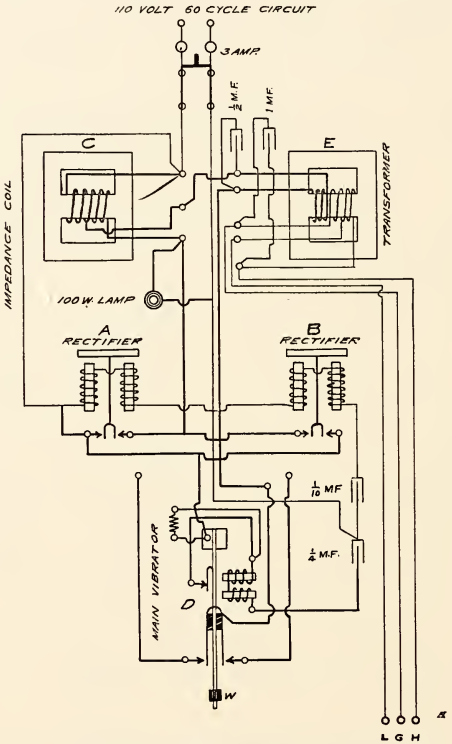
*Telephony, McMeen and Miller.



LEICH FREQUENCY CONVERTER

Fig. 4.

Auxilliary Signalling Currents

Auxilliary signalling currents are such as are used for busy signals, howler for "receiver off," tone test, etc. These are all of higher frequency than those currents used for ringing bells. The required interruptions are best produced by rotating commutators of different speeds, working together; the latter being ordinarily associated with the ringing generator because of its constant operation.

Tone test is set up by sending current from the office battery thru the high winding of a special transformer, the resistances of whose windings are 1030 and 1/3 ohms, thru an interrupter wheel on the shaft of the ringing generator to ground. The interrupter wheel opens the circuit from 400 to 800 times per second, and this results in an alternating e. m. f. of the same frequency in the low winding of the transformer. Busy back is set up in somewhat the same manner except that the wheel gives a frequency of from 150 to 200 per second, and to give the interruption to the buzz, a portion of the circumference of the wheel is left solid. For the howler circuit, the interrupted current is often taken from the high speed wheel.

Power Switchboard:

The power board carries the switches, meters and some of the protective devices which controll the exchange machines. The switches consist of those necessary for controlling the several driving motors, and those used to throw the various loads to the regular or emergency units. The motor starting rheostates are mounted on the board, as well as circuit breakers and fuses for the charging leads. The meters are usually of the Weston station type Voltmeter and Ammeter, used for reading terminal voltages and loads respectively. Each instrument is connected thru a dial switch to facilitate reading the various machines and sections of battery by simply turning the indicator of the switch to the machine under observation. The voltmeter is commonly used to determine the condition of the battery or its cells, and to read the generator e. m. f. when starting a charge. An ammeter makes possible a normal charging rate, and provides a means for reading the discharge. The circuit breaker is arranged to work in conjunction with a polarized relay so that it drops when the generator voltage becomes lower than that of the battery. All fuses and circuit breakers are provided with alarms so that their opening becomes known and the restoration of service may be immediately effected.

Provision Against Breakdown:

In order to provide against breakdown of apparatus or failure of commercial power, every telephone exchange is provided with emergency equipment for every kind of current used.

To insure against power failure due to local distribution trouble, two entirely separate power leads are sometimes run into the office from different parts of the system. If this is not done an emergency gas or steam unit is furnished to supply the office needs. In addition to these provisions, the storage battery is designed to carry the full office load, including all emergency machines, for a period of 24 hours. It is of equal importance that the supply of ringing current shall not be interrupted. Usually one unit is operated from the commercial power lines, and the other from the office battery.

Capacity of Power Plant

The power plant is designed to be readily increased in capacity to an amount sufficient to provide current for the ultimate demands of the office. In the case of the storage battery however, it is common practice to install the ultimate capacity of tanks, but to provide plates only sufficient to handle the load at installation, with a slight excess. Thus the battery capacity may easily be increased without interruption of service or extraordinary provisions.

An idea may be gained as to the actual sizes and capacities of machines in a telephone exchange by the following tabulation. These comprise the installation at Douglas Office, Chicago, Ill., an exchange of 10,044 stations, 40 private switchboards, and 7650 coin collecting boxes; the average peak load being 180 amperes.

Regular charging set: Western Electric generator, 30 volts, 250 amperes, 1400 r. p. m. Motor driven from the Commonwealth Edison D. C. lines, 220 volts.

Emergency charging set: W. E. Co. generator, 30 volts, 400 amperes, 1150 r. p. m. Driven by a vertical Nash gas engine operating from the Peoples Gas Co. mains.

Regular ringing generator: Alternating current at 80 volts, 20 cycles. Driven by a 1 H. P. shunt motor operating from Edison mains at 220 volts; 1200 r. p. m.

Emergency ringing machine: Operated by a ¾ H. P. motor running on the office battery at 19 volts, 42 amperes, 1200 r. p. m. Both machines operate the auxilliary current interrupters at one end of the shaft.

Regular Message register generator: W. E. Co. ¾ K. W. 1750 r. p. m., 20.8 amperes, compound-wound to maintain a constant voltage of 40. Driven by a 1¼ H. P. motor, shunt-wound, 220 volts, from Edison lines.

Emergency message register generator: same as regular, run by a 1¼ H. P. motor operating from the office battery at 19 volts and 79 amperes, 1750 r. p. m., shunt-wound.

Test ringing generator: Alternating current at 100 and 70 volts, 1275 r. p. m. Driven by a ⅝ H. P. motor, compound-wound, 220 volts, operating from Edison service. No emergency machine.

Storage Battery: Eleven cells each having 26 plates of dimensions 15 in. by 15 in. Three sets of coin collection battery of 55 cells in series, giving 110 volts average. Each cell of 2 plates of dimensions 3½ by 4 inches. A set of special cells to operate auxilliary coin detector lamps on cord circuits, terminal voltage of 48. This set is also used as a booster on long trunks and to charge private exchange switchboard batteries over cable conductors.

Automatic Telephone Power Plant

Automatic telephone practice has endeavored to introduce electrical self control into its power plant as well as to the connection of lines. The following description of a small automatic power plant is given by Mr. A. B. Smith, in a pamphlet of the Automatic Electric Co.

"The current is supplied to the Automatic switches by a 24-volt lead storage battery, with a controlled pressure of from 46 to 52 volts. To secure the highest efficiency at the lowest initial cost, the battery is floated on charging current most of the time. When the pressure falls to 46 volts, a voltage relay causes a motor generator to start charging the battery. While charging is going on two counter e. m. f. cells are cut in between the battery and the switchboard to prevent undue rise in voltage. When the pressure arrives at 52 volts, the voltage relay stops the motor generator and the counter e. m. f. cells are cut out of circuit. By these means the pressure on the bus bars is kept between the prescribed limits. There is a voltmeter across the bus bars and an ammeter in the battery lead. The latter has its zero in the center of the scale so as to indicate current flow into and out of the battery.

A small rotary converter operated off the storage battery provides ringing current and the busy tone. The current from the slip rings of the converter is led thru a small transformer, which steps it up to approximately 100 volts. A cam-operated spring actuated by a slow moving gear on the converter interrupts the current so as to produce the periodic ringing so characteristic of the Automatic telephone. The period consists of a little over half a second of ringing followed by two and one-half seconds of silence. The frequency is twenty cycles per second. The converter runs only while connections exist, being idle and consuming no current at all other times. If no other connections are up, the rotary converter starts when the connector switch makes its first upward movement and stops when the connector releases.

The busy tone is created by the rapid interruption of direct current thru the primary of an induction coal. Mounted on the converted shaft is a commutator with many segments. The 48-volt battery current is led thru this in series with the primary of the induction coal and a pair of interrupter springs. The latter makes the tone come and go periodically, causing it to be recognized clearly as a busy tone. The secondary of the induction coil is led to the connector switches."

MAINTENANCE FEATURES

In the foregoing, an attempt was made to cover in a general way some of the various types of telephone power plant equipment. To present an idea of the maintenance features requires a more localized view however, and in the following discussion the material will include something of the present practice in the Bell System, with which the author is most familiar.

Direct Current Supply

After the battery is in commission, the charging periods should be carefully watched. Excessive charging causes disintegration, while undercharging results in sulphating of the plates and a decrease of capacity; if the undercharge is great, disintregation also results. It is therefore essential that the battery be charged at regular intervals and at the rate specified.

In order to provide the proper regulation, the charges are divided into two classes, namely, regular charges and overcharges. The regular charges occur daily and restore the capacity of the battery after discharge. The overcharges which occur every week or two, according to the use of the battery, insures that all cells have received their proper charge for reducing such sulphating as may have occured. The specific gravity of the electrolyte, voltage of the battery and gasing are all indicators of the general condition of the battery, and are always observed when making inspections. Either or both the voltage and specific gravity methods are used as indicators.

In starting a regular or overcharge, the following routine is gone thru; the principles involved are very elementary but must be observed.

Read the voltage of the battery to be charged by turning the dial on the voltmeter switch to the contact marked to correspond to the battery that is to be charged. Set the indicator of the meter opposite the voltage obtained, then turn the voltmeter switch to the point marked to correspond to the number of the charging generator that has been started, and adjust the voltage to about one volt higher than that of the battery. This is done by turning the hand wheel of the field rheostat associated with the generator in the direction indicated by arrows on the dial plate to raise the voltage of the generator. Close the proper switches according to the markings on the power board to connect the generator being run to the battery being charged, and then increase the voltage of the generator until the current reaches its desired value, as shown by the ammeter. If using an emergency gas engine unit, the same operations are gone thru as for the motor driven generator. A precaution should however be observed. When starting, the brushes of the generator should be raised off of the commutator surface until the engine has attained running speed. This is done in order to protect the commutator and brushes from being run against each other thus marring the surface or bending the brushes, due to the oscillatory motiion of the engine wheel when starting or when being shut down.

Charging is usually done during the small hours so that the rise in voltage which occurs during the process may come at a time when the traffic is light; and then float the machine by so regulating its voltage that its output will about care for the office load. This keeps the voltage during the day fairly constant at about twenty-four volts, economizes both machine and battery capacity, and avoids the conversion losses which are inseparate from a heavy battery discharge and charge. In this method the battery serves during the period of heavy traffic merely to smooth out the irregularities in the current, which is

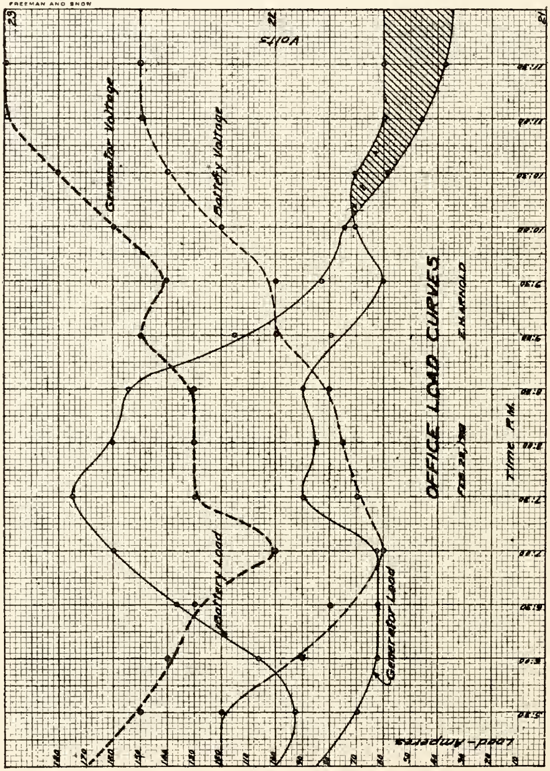


Fig. 5.

furnished directly by the machine; to act as a reserve during the day, and to carry the office load only during the light traffic hours of the night.

Herewith is shown a typical office load curve, together with a curve of generator output. The instructions in connection with this battery call for a regular charging rate of 120 amperes, and an overcharge rate of 160 amperes. At four o'clock the generator output was set at 120 amperes, but as is seen this rate was not maintained. The fluctuation of the output curve with respect to the battery drain is due partially to variations in power line voltage, but mainly to the changing e. m. f. of the battery. At midnight, the generator is shut down and the battery carries the office until 6:00 A. M. The shaded portion of the area between the curves indicates part of the regular charging period, that is, the part which comes on during the evening; a greater area occurring during the afternoon. Since the regular charge is so easily effected by load conditions, it is easy to appreciate the importance of the overcharge period to the maintenance and life of the battery.

If two generators are to be operated in parallel, one is started and connected to the battery as outlined in the preceding paragraph. Raise the voltage until the machine is charging at a rate not to exceed 100 amperes. Then start the other machine and raise the voltage until it is about one volt over the voltage of the first generator, then close the generator switch and raise the voltage until the second generator is carrying an equal portion of the charge. The voltages of the two generators should then be raised until the desired charging rate is reached, the total charge being equalized between the two by raising one and lowering the other as the case may be. The machines should be checked periodically to see that each carries its share of the charge and that the capacity of neither generator is exceeded.

To take a generator off the system, turn the ammeter switch to the machine in operation, and reduce the voltage until the ammeter reading indicates current reversal. At this instant the circuit breaker will operate, the charging switch is then opened and the breaker restored. To shut down two generators operating in parallel, reduce the voltage of both machines until the load is about 100 amperes each. Then take off each separately as above.

As has already been mentioned, the sensitiveness of telephone apparatus to uneven and fluctuating currents, make the care of the generator one of the important items in office maintenance.

The bearings must of course receive regular attention in regard to oil supply and cleanliness. Periodic inspection of the oil rings is necessary, for they are the prime factors in this kind of shaft lubrication. The more important part of the machine is however, the commutator and brushes, that is, in connection with the realization of absolutely sparkless commutation. Assuming that the machine has been properly designed and that this commutation is attainable, the following points are of value in its maintenance.

Brushes should be straight in the holder and so seated that all of the bearing surfaces are in contact with the commutator. A jig is provided which should be used in shaping the brushes on charging generators to fit the curvature of the commutator. Brushes should be approximately 1/16 inch thick after being shaped, and should never be allowed to become thinner than 1/64 inch, nor should they ever be allowed to become frayed. After the brushes have been shaped and fitted, they should be cleaned of all grit and dirt with kerosene before being installed. The heels and toes of all the brushes in each stud should be kept in alignment. Brush stiffeners should be so placed that they extend to about ½ to ⅜ inch from the toes of the brushes. The tension of each brush should be from ½ to 1½ pounds per sq. in.; this can be measured by using a suitable spring balance.

Brushes should not overlap the ends of the commutator when the machine is in operation. They should be staggered so that all parts of the commutator receive an equal amount of wear. At least once each month, all brushes should be removed from their holders and all dirt, oil, etc., removed from the contact end of them. by soaking them in kerosene. Telephone gauze, or copper brushes should be mounted so that the direction of rotation of the commutator is away from the toe of the brush.

At the beginning of each run and about once per hour during the run, the commutator should be lubricated by holding a piece of cloth or canvas against it while running. This cloth should be moistened with a mixture of 80% light oil and 20% kerosene, or other approved substitute. If the commutator shows a tendency to gum up, or on the other hand to show wear, an adjustment of the mixture may be made to suit the condition. If properly attended to, the commutator will soon acquire a hard dark polished surface. If the surface becomes uneven, it should be turned down and made true before the cutting becomes too deep. Sandpaper should not be used on a commutator after it has taken on the polish and will seldom be required. Emery cloth or emery paper should never be used on telephone generator commutators.

Storage Battery

Probably every type of battery has its list of instructions which must be followed to obtain the best service from the equipment. The following points are however applicable to most all makes of lead cells used for telephone purposes.

The height of the electrolyte in the pilot cell is kept at a fixed point, usually ¾ inch above the top o fthe plates, by the addition of small quantities of distilled water each day. This is usually cared for by automatic fillers; if it is necessary to supply water manually, it should be done at the beginning of the overcharge. Before starting the overcharge a careful inspection should be made with a lamp and extension cord, and any short circuits which may be found should be removed by means of a strip of wood or hard rubber.

Trouble in the battery is usually indicated by a falling off of specific gravity or voltage relative to other cells in the battery. A lack of deficiency of gasing on overcharge as compared with other cells. The color of the plates, markedly lighter or darker than in other cells is often indicative of trouble.

Gravity readings of the pilot cell are taken by means of a compensating hydrometer. Check the adjustment of this instrument with the ordinary hydrometer corrected for temperature. The compensating hydrometer should not be removed from the pilot cell to read other cells, as this is liable to affect its adjustment.

The collection of sediment should be carefully watched and not allowed to rise to the bottom of the plates. When it has reached to ½ inch of the bottom of the plates it should be removed at once. With small cells this can be done by carefully drawing off the electrolyte; if the plates are large and set in wooden tanks the sediment may be removed by means of a scoop made for the purpose.

CONCLUSION

The high grade apparatus which is the result of modern methods of manufacture, has reduced failures to a minimum, and as long as proper attention is given to operation, disasterous breakdowns are almost unheard of. The principles involved in the maintenance of a telephone power plant, as such, do not differ materially from the fundamentals which apply to the care of any other organization of machinery and apparatus. A great application of time and labor at arbitrary intervals will soon manifest itself in a poorly running plant. What is needed is constant attention at stated intervals, the correct amount of lubricant applied at regular times, and readjustments when trouble begins to develope, rather than the replacing of a part after it has been destroyed.

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Kellog Switchboard and Supply Co.
Century Telephone Construction Co.
Leich Electric Co.
Holtzer Cabot Electric Co.

INITIATIVE.

Opportunity is looking for the man with initiative.

She needs him even more than he needs her.

And who is the man with initiative?—Simply the man who can do the right thing, at the right time, in the right way, without being told. He is the man who does not wait upon his "boss" to tell him *how, when* and *what*—to do.

He relies upon his "boss" to *aid* his plans, but not to *make* his plans.

If you can follow instructions, and follow them well, you are above the average; there will always be a place for you in the world of affairs.

But, if you can *exceed* your instructions in doing the things that ought to be done, then you are among a chosen minority. Destiny has picked you for special preferment—you have initiative.

Initiative is the power to *create*, all else is but the ability to *imitate*. And for every man who can create an idea, there are a thousand who can skilfully imitate it. For each person who can move forward on his own impulse, there are scores who can go ahead if only some one else will supply the impulse. This is the same as saying that real initiative is very rare; therefore it is in general demand.

We need in this world the men who can "carry the message to Garcia," but still more do we need the man who can furnish the message.

Cultivate, therefore, the habit of being a self-starter in both thought and action. I give you a simple test; think of one *new* thing, today, which *you* can do for your Company's interests.

Then *do* it.

That will be initiative; and you will find that it is made up of about one part superior ability and three parts superior determination.

Repeat the test tomorrow, the next day, and the day after, until it becomes the habit of your thought and life to explore new fields and break down old ruts. That will make of you a success as your *own taskmaster,* which is the first great stepping-stone to other successes beyond.

J. Ogden Armour.

The Armour Engineer

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Armour Institute of Technology

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The technical press is invited to reproduce articles, or portions of same, provided proper credit is given.

We have assumed the privilege of wandering from the purely engineering field, in this, our last issue of volume X, and have made it our war number. Due to the steadfast loyalty of the alumnus, this paper has successfully withstood the depredations incident to these abnormal times, and we have been so fortunate as to continue our publication as in the past. The May number is intended largely as an Alumnus Number, and as such we have attempted to record such facts and matters of interest to the alumnus, as are fitting at this time.

We are pleased to call especial attention to the editorials by Dean Monin, and Dr. Scherger, and to the story by Col. Visscher. It is interesting that Dean Monin should recall to our minds the fact that this year marks the 25th anniversary of the foundation of the Armour Institute of Technology. The article by Dr. Scherger is taken from an address delivered before a body of some of the most prominent men of Chicago. The story by Col. Visscher is a record of an interesting series of events as they transpired while he was serving with the Union Forces. Private Brock was at that time under the command of the author of the story, here published for the first time.

With the co-operation of the editors of the Cycle, we have compiled an Honor Holl, as nearly complete as is possible at this time, when the men are leaving for France and when men of training are constantly obtaining better positions in all the various branches of the service.

With the editorials, the usual articles of technical nature, and the Honor Roll, the present staff submits its final issue to the readers of the Armour Engineer. We hope the degression of this issue from the standard technical nature of the paper will be appreciated in the manner in which it was intended. We considered such a procedure not only fitting, but, at this time, essential.

At this writing, two members of the staff of the 1918-1919 Armour Engineer have been appointed by the executive council of the Armour Institute of Technology. They are:

William Mendius .... *Editor-in-Chief*
Robert H. Rensch .... *Managing Editor*

Those of us who have seen the Cycle of this year are assured of the success of Volume XI of the Armour Engineer; may we all unite in extending these men a hearty welcome to their pleasant duties.

TWENTY-FIVE YEARS OF A. I. T.
(A RETROSPECT AND A PROMISE.)
BY LOUIS C. MONIN.

With the close of this college year, the Armour Institute of Technology completes the 25th year of its existence.

Twenty-five years! A long time in the life of man, but a very short time in the life of an institution. It is not my aim to sketch a history of the Institute in this number of the Armour Engineer. All I wish to do is to call the attention of our Alumni and friends to the fact that the first quarter of a century in the life of their Alma Mater has come to a successful end. We have all reason to be proud of the remarkable progress made not merely by the Institute as such but also by its graduates, who at the present time number more than twelve hundred. Most of them have found out that education is "less of a drawback than one would think." Therefore, we all look forward with perfect trust to a glorious future for them and for the school.

What we have learned is "that faithful duty really counts and not dollars and the shouts, and having our name in the encyclopedia." The kind of success we are all looking for is not always gilt-edged, and the band isn't always playing for us to march by

The story of Armour Institute of Technology is a good, clean, honest story: "A story of devotion and loyalty, and of the kind of courage that holds out when nobody is looking on or waving hats." We may truly say that the work done in the different engineering departments is thorough and up-to-date. While the surroundings and appointments are in keeping with its character of usefulness and efficiency, and while it cannot be said that our light has been very brilliant or very far-reaching, we may yet be proud of the fact that it has been *steady* and *will remain so in the future*. The road from now on may grow steeper and the fight may wax warmer. Competition is everywhere, and he who aims for high achievement must not be surprised when he finds that the law which physics has taught him is true everywhere in life; namely, that force can only be exerted against resistance. It is often claimed that the curriculum of an engineering college, and especially that of the Armour Institute of Technology, is rather exacting and puts a heavy strain upon the energy, patience, and time of the young students. However, we have yet to find one of our graduates who is not grateful for the chief elements of his education obtained during his college course at the Institute. These elements are the power of close attention and the insight that "any principle which secures the safety of the individual without personal effort is disastrous to moral character."

It is not necessary to give statistics in order to show with what enthusiasm and patriotic devotion graduates and students responded to the call of our country. Suffice it to say, that over three hundred are already in actual service. They have all gone forth from the college halls with the conviction that theirs is a man's task. They are well equipped mentally and morally. The only excess baggage they carry is hope. As they are prepared for hardship and danger, so the institution, as a whole, is ready to stand the test of hard work, of toil, and strife, and of ultimate achievement. We may not be able fully to realize our ideals, but we can at least make an honest attempt to idealize our reality. And this the Armour Institute of Technology has consistently done during the first twenty-five years of its existence. Let graduates, students, and faculty remember upon this important occasion the words of Whittier:

"The tissue of the life to be
  We weave with colors all our own,
And on the field of destiny
  We reap as we have sown."

AMERICAN IDEALS.*

By Dr. George L. Scherger.

Professor of History and Political Science, Armour Institute of Technology.

We are living in the greatest period of the world's history. The Civil War, the Napoleonic wars pale when compared with this era. My father was a veteran in the Civil War, and I remember how he often told me about the battles in which he had participated. I remember the feeling I had when a boy, of what a wonderful opportunity it must have been to be alive in those days. I remember when in my boyish days I read about the exploits of Napoleon and felt that was a wonderful period, but we are living in a vastly greater period than any of these were. America has been drawn into this great world war. It is a time of testing. We realize as never before what Darwin meant when he spoke of a struggle for existence. It is a great test. It is not only armies that are fighting against one another. It is not only generals opposing one another but it is nations.

In this new era the armies of Napoleon seem very small, when you remember that in 1812, he invaded Russia at the head of an army of half a million, and he called that "Le Grande Arme" and he thought it was the finest army in all the history of the world. What does a half a million men seem to us today?

But it is more than all this: It is a testing of forms of civilization, and so we wonder what sort of a part America is playing and it seems to me nothing could be more appropriate than to ask this question: What are our ideals and principles as a nation? What is America's part among the nations? What is the American spirit. Is there anything we stand for particularly?

Now, no two individuals are exactly alike; as I look over this audience I find that every face differs from every other. No two nations are exactly alike. We are different even from our neighbor, Canada. Just think of the one tremendous difference in our form of government, that Canada should have the English cabinet system of parliamentary government and we should have the system of checks and balances, the system of the separation of power, as we call it. We have many points in common, and yet we are different.

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*Address delivered before Annual Dinner of Chicago Real Estate Board.

Rome had her mission to perform in the history of the world. She built up the greatest empire the world had seen; she broke down national barriers in those days when race prejudices were so terribly strong, when the Greek called everybody who was not a Greek, Barbarian, the word being of Greek origin. When the Roman had a word "inimious" which meant not only foreigner, but enemy; when the Jew called all other people, "Gentiles."

Rome conquered all these nations, brought them into one form of government, almost the entire world, under one form of government, and then after she had brought them together, had to learn how to give them laws, the most equal and wonderful legal system the world has ever known,—this system of Roman law which for over a thousand years, was the best of the legal systems of Europe, with the exception of England, and in many countries of the continent of Europe, the Roman law is still the best.

Greece, on the other hand, took up the problem of human culture. That was her contribution to civilization.

England has worked out the problem of constitutional government,—parliamentary government. England long ago had that problem to solve,—how can we end the autocracy of the King? Back in the days of King John, and before the days of King John, that question came up,—how can we prevent the King from doing what the people do not want him to do? They made him sign the Magna Charta in 1215, but John knew that it is one thing to sign a document, and another one to keep **a** promise.

The Magna Charta had to be signed two hundred and twenty-five different times, and was broken again and again by the various Kings of England. In fact, England owes more to her bad kings than she does to her good kings. It was in the reign of King John that she obtained the Magna Charta. It was in the reign of his miserable son, Henry the Third, in 1265, that the House of Commons came into existence, and so on. It was in the reign of George the First that this problem finally reached a wonderful solution as the result of a happy accident,—what we call the English cabinet system,—the English system of parliamentary government developed, and by the way, it seems to me from my study of history, that most great problems solve themselves, in some fashion or other. I mean to say that humanity stumbles upon a solution, as it were.

Here for hundreds of years, the people of England had asked the question,—how can we make our King behave? How can we make the King do what the nation wants him to do? They said from the days of James the First to Charles the First, "It is his wicked advisers doing that,—Buckingham and the rest of them; let us impeach these fellows; how can the nation get control of the King?"

They cut off the head of Charles the First, but you cannot do that every time the King misbehaves. They threw James the Second out, then didn't know just what was the matter. The Throne in England is not supposed to be vacant, unless the King dies or resigns, and James the Second did not think of resigning, so they resorted to a sort of legal fiction in saying that it was a resignation, and in 1688, in their glorious, bloodless revolution, they made William and Mary sign a document known as the Bill of Rights, but it was as an accident, that in the reign of George the First, this problem solved itself in a wonderful way.

George the First was Duke of Hanover, before he came to England; he was a foreigner—a German; he did not like England; he didn't care for England; he did not know much about it. He was glad to have Robert Walpole, the leader of the strongest party in parliament, the Whig party, to which he practically owed the throne, to relieve him of the cares and burdens of government. He was content with the civil laws and to draw his salary.

So it happened for the first time in the history of England, that you have a Prime Minister; the leader of the strongest party selects the members of the cabinet, the heads of the different administrative departments, and ever since that time in England, the power has dropped out of the hands of the King and the responsibility of the Cabinet to parliament was enforced.

The people of England, in some respects, have a government that is more democratic than our own; that is, the will of the people is carried out more quickly than it is here. If they want to change their policy, they can do it tomorrow. They can turn out the government tomorrow if they want to. If we do not like our President or our Senate or our House, we have to wait until their term of office is over, but under the English Cabinet system, they can turn out their government, and, that does not mean the King. It means the Prime Minister and the Parliament,—at any moment they please. That, I take it, is England's great contribution to civilization and the history of the world.

In the United States we do not have that system. Strange to say the President of the United States does just what the Kings of England did before Geoge the First, he selects the members of his own cabinet, and can keep them in office as long as he likes. Neither Congress nor the people can force the President to oust his entire cabinet, or any member of that cabinet. But this subject, interesting as it is, and having a direct bearing upon what is happening in the present time, I must leave, and my question is, what has America done for the world? Is there anything we stand for?

Now we have that word "Americanism" and the nations of Europe for at least fifty years or more have known what Americanism is. Anything that was done along the line of industrial enterprise, they called "Americanism." When the first great department stores went up in the European capitals, such as Berlin, London, Paris and so on, that was an American enterprise, and any big thing along the line of industrial work, they seemed to think a symbol of Americanism. They thought we were a nervous, excitable people, that loved to do big things once in a while, but lacked thoroughness.

There is something more than that about Americanism. The most wonderful definition of Americanism has been given by Abraham Lincoln, when he said that we must see that government of the people, for the people and by the people, shall not perish from the earth. That is true Americanism. Faith in the common people, and I take it, that if all our American jurists and political writers, had said nothing else but that one phrase of Lincoln's, it would be a decided contribution to the history of the world.

Governments have been for the people professedly, although they have not been by the people. In the 18th century, we have what we call "Enlightened Depotism." Frederick the Great of Prussia, Catharine the Great of Russia, Joseph the Second of Austria, are what we call enlightened despots. They said, "We want to do everything for the people," and they instituted reforms right and left, but they said, "The people are children; they do not know what is good for them; we must take care of them."

Now that is not in accordance with our American ideals, and with Abraham Lincoln's definition. We believe that the government ought to be carried on directly by the people. The people may make mistakes. They will make mistakes. Sometimes I think that our government by the people is more expensive, more costly even than a bureaucratic system of government by trained officials, such as they have in some of the Continental countries of Europe, but if we make a mistake, it comes right home to us. We cannot blame any one else but ourselves, and so we learn from experience .

Democratic government is government by public opinion. It is a government based upon the consent of the governed, and it has this wonderful educative value. Now I do not believe that democracy, which rests upon the idea of equality fundamentally, means that any man is good enough for any of us. Do you know that in the days,—the balmy days in Athenian history, when Pericles and Socrates lived, they had even more extreme notions of democracy than we have. They did not have representative government in those days, but every Athenian citizen got together with all the others, a few thousands of them, and they made the laws directly right there on the public square, and when an office was vacant, they filled it by lot. Now we do not believe in that. We would not take any Tom, Dick or Harry to make him Mayor of Chicago or Governor of Illinois or President of the United States.

The fact is, we realize today we can scarcely get men big enough for these offices. We are realizing as never before that we cannot be too careful who we put in charge of these public offices, so I take it we do not believe in that kind of democracy, but we believe in the democracy that will get us the right kind of leadership, and there never was a time when the need for great men, for big men as leaders, was felt as it is today.

And so I take it, that more and more we will see, that as America has left her isolated position in which we were up to this time, and has become a world power, we will realize the need of putting these important matters in the hands of the very biggest men we can possibly find.

Then there is another glorious word we are using today. We ought not to use these words without knowing what they mean, —and that is the word "Liberty."

Madame Roland, one of the great leaders in the French Revolution, once was regarded as a radical, but events moved as quickly as they are moving in Russia, and then she and the rest of the Girondist party were engulfed and she was sent to the guillotine, and you remember her last words: "Oh, Liberty, what crimes are committed in thy name." We must not use these words without knowing what they mean.

We do not believe in liberty of the extreme form, which would mean the right to do as you please; we believe in a restricted liberty. The question is, how much freedom shall the individual enjoy? We Americans, together with our Canadian and English friends, have believed in individualism. Individualism is a spirit, rather than a form of government,—the idea that the individual shall not be put under too much restriction, but shall be given a wide leeway. Way back in the early part of the 19th century, there was a school of philosophers in England, called the Manchester School, and you know John Stuart Mill expresses that in his book on "Liberty." He formulated the idea: "That state is best which governs least."

This was a vast country, America. Our population a hundred years ago was very small. We did not have even as good a police force then as we have now in Chicago. It was difficult to police so large a state as that, and we left people to themselves, and it is remarkable how well they go along. And so way back in Colonial times we got used to this boundless freedom, and that is one thing for which America stood,—let every man do as he pleases.

We are getting over that extreme individualism, and this war is bringing a wonderful reconstruction, a fundamental reconstruction. The tendency, as I see it today all over the world, and we are getting it here in America, is towards a greater concentration, towards a greater socialization of activities. The question is not any more, what do you want to do, but the question is, what must you do? It is not left to voluntary enterprise, but we are feeling that the most satisfactory results can be obtained only when the hundred million people of the United States work as one and almost over night, it seems that our development has been a most astonishing one. The government the other day took over the railroads. In Canada I notice that the same movement is impending. At the very beginning of the war, we decided upon conscription. The old system of voluntary service was at once given up, and conscription adopted. To-morrow, the government may take over the mines and other industries. And so we see that the movement is all along the line of concentration and socialization.

After all, one of the greatest master minds of our age was the Jew, Karl Marx, who predicted almost half a century ago, that this very thing would come about, and it is coming. It is a tendency in the other direction. This drastic order which was issued the other day, with reference to the coal question, would have been inconceivable half a year ago, and we see that under the stress of war, sometimes it is necessary to do certain things and to do them quickly, that you would not think of in peace times.

We do not love war. War is distasteful to the American temperament. We were not a militaristic people. We thought we were safe and we did not need a large army. England thought the same thing. With the exception of a brief period in the days of Oliver Cromwell, she did not know what military rule was, and now, over night, these thnigs have changed.

So I think we will have more of this knitting together, this welding together. It is not the old atomic theory of government any more. That is what individualism was,—a hundred million atoms, but we must fuse into one great whole, we must act and think as one, and so, a fundamental reconstruction is going on.

Alongside of a political movement, there is an even more important economic movement. You find it in Russia; you find it in England. In England the power of the aristocracy has rapidly waned. Those large estates,—a hundred thousand acres of land, a hundred and fifty thousand acres of land, belonging to one nobleman, used as his hunting preserves, are now being broken up. As the necessity of getting as much food as possible develops, these large estates are being cut up into small farms. Lloyd George saw that problem long before the war when he made the attempt to see that land was taxed at something of its real value in England, not at a nominal sum. And as our boys are fighting in the trenches, the son of the plutocrat, the son of the Duke or nobleman, alongside of the farmer boy, a new feeling of brotherhood and democracy is coming to the world. The great French Revolution of one hundred years ago was a protest against privilege, and the idea of privilege has not yet entirely perished from the earth, so I see everywhere a wonderful economic reconstruction coming on as the government more and more takes charge of these great activities; with the high rate of taxation, which is necessary to maintain the war, and so that means that America will be solving, better than ever before, her fundamental problem, to make life more worth living for the average man.

Abraham Lincoln said: "God must love the common people, because he made so many of them." We do not believe as Americans, in having just a few aristocrats, whether they belong to the aristocracy by birth or of wealth; but we must see how this new problem of democracy is applied to the great mass of our population, and so this victory of democracy the world over, is going to be a glorious victory, and the world is going to be a better world to live in because of it. Let us be truly patriotic. Our policy is an American policy and *must* be an American policy. We have a very cosmopolitan population in the United States. That makes our problem more difficult than that of any other country that is taking part in this war. There are millions of Americans trying to see their way clear, as to what their duty is, and their hearts are bleeding. Let us not forget that question, that fundamental situation here in America, due to our cosmopolitan situation. We are not as homogenous a people as the French or English, or the Italians or Germans are, for that reason, and so in this war and every other way, there is only one policy, and that is a purely American policy, and there is nothing else that will weld together these different ethnic strains in America as much as that. You can appeal to any one and get him to see his duty, when you realize what our American interests are.

A PRIVATE AND A PRESIDENT

By William Lightfoot Visscher.

Garfield.

When carved and moulded mimicry of life,
High on the lofty pedestal of fame,
Shall melt and crumble in the tongueless dust,
Full many a grand and glorious name
Of fair Columbia's hero sons shall live,
All deathless in Eternity's great breast,
Immortal as the blessed angels are,
And Garfield's name will be among the best.

It was the summer of 1862. The armies of the Tennessee and the Cumberland had just passed thru the campaign that followed the occupancy of Nashville by the Union forces. Buell's army it was that had made a forced march of ten days from Nashville to Pittsburg Landing, the last twenty-four hours of which had been "double-quick" a great part of the time, much of it thru mud and rain accompaniments to the field of Shiloh, there to relieve Grant's stricken army and to retrieve the first day's disaster.

Thru that bloody field and the evils that followed it: mud, cold, hunger, the most terrible deprivations and discomforts, indeed, known to soldier life in times of war, came the siege of Corinth and the capture of that position, then the battle of Iuka Springs, the march to Tuscumbia, Decatur and Huntsville.

It was within a few miles of the last named place that the army lay encamped in the early days of July, and in a level valley there were wide stretches of plain and here and there forests of towering live oak bannered with the trailing Spanish moss.

Here the Fourth of July was celebrated in an almost homelike way.

A stand was erected beneath the trees and seats were improvised of logs rolled up and arranged in rows and of poles lain from wooden forks driven into the ground. The stand was arbored with boughs of green and "Old Glory" was tastefully woven and draped among them.

The orator of the day was a young brigadier named Garfield, and his voice, in patriotic eloquence, rang out over the vast audience of bronzed soldiers like a silver bell. He said things that brought such cheering as one only hears in an army. It was sincere, wholesome and enthusiastic.

There is a well-known old story of those time, in those armies, that a visiting governor of a state while riding along the lines with a General of Division, hearing a wild and prolonged cheer in the distance asked what it meant.

"Only Rousseau or a rabbit" was the laconic response.

Such was the popularity of General Rousseau of Kentucky, in that army, and so gallant and chivalrous his appearance and bearing that wherever he rode among the troops that were not constantly with him, long and succeeding cheers followed him down the lines; when upon going into camp, at any time, a rabbit, or ever so many rabbits, were started from their hiding places the soldiers, cheering and yelling as if they were making a charge, would chase Mr. Rabbit by battalions till often that proverbial sage and strategist of the animals would stop, overwhelmed by fright, and allow himself to be picked up, just as "Brer Fox" took him from the sticky embrace of the "Tar Baby."

This explains the Division General's reply to the Governor as to "Rousseau or a rabbit."

The applause during Garfield's Fourth of July oration were such cheers as those for Rousseau and the rabbit blended, with an extra volume thrown in, and those cheers seemed to follow him as they did Rousseau and the rabbit, wherever he appeared during the remainder of his stay in the army.

Private Brock, of the Kentucky Infantry, had been generally considered by his comrades a diffident man; one who would prefer to face a battery of artillery that was throwing chain-shot and shrapnel from short range, rather than to approach a woman or a man of exalted rank. But Gen. Garfield's Fourth of July oration had enthused Private Brock to such a degree that he threw off all the trammels of restraint and watching his opportunity he approached the orator-general as rapidly as he could when the young brigadier had descended from the speaker's stand, intending to offer his congratulations in his own Private Brock way.

Gen. Garfield was about to mount his restive and spirited charger to ride away to his own camp when the excited animal made a leap, startled by the sudden bursting forth of blasts from a full brass-band—full as to numbers, as to enthusiasm, as to liquid commissary stores that had been dealt out, extra.

The brigadier's left foot was already in the stirup and the leap of the horse was almost dragging him to the ground. But Private Brock was there. He was a powerful man. With his left hand he caught the bridle, close to the curb-bit and with his right he caught the gallant officer, thus averting a painful fall for the rider and bringing the horse to a sudden stand-still and almost thrown upon its haunches.

"I am very grateful to you, comrade," said General Garfield, as soon as he had recovered his equilibrium.

"Don't mention it," said Private Brock. "I'm glad it happened."

There was a general roar of laughter at this very blunt admission and Brock, seeing that he had made some sort of mistake, added, as the flush of his face about equaled the red of the huge bandanna around his neck: "That is to say, suh, it could'nt er happened at a better time, suh."

"I'm decidedly of your opinion, comrade. What is your name and command?"

"Well, suh, that wuzent 'zackly whut I come heah to tell you, suh, by my name's Brock, suh; jes' Private Brock of Comp'ny K —Kentucky, suh. But I wanted to say—"

"Go ahead and say it, my friend. You are all right."

"I'm most'ous glad to hear you say so, Gin'l, suh. Whut I want to say is, suh, that a man whut kin make sich a speech as that'un er yourn, up thar, suh, oughter be back yander, up Nawth, larnin' them blame copperheads some er this yer truck you ben tellin' us today. We know all about it. Them's the fellers that needs it. Go back thar, Gin'l, suh, an' po' it into them, red-hot. You kin resign. I can't. Ef I could I'd go with you, fur I'm no slouch of a talker, myself, when I git started, ef I do say it, as maybe ortn't, suh."

"I see you are not," laughingly put in the general.

"Yes, suh," continued Private Brock, "You're the best single-footed talker at I evah hearn, Gin'l, suh, 'an I'm er shoutin' fur ye f'um A to Izzard. Go back thar, suh, an' run fur Congers, er somethin', an' shoot it to 'em, bilin' tabasco an' plenty. You kin do it, Gin'l, suh. Ef you should evah want me to hep you—ef it aint nothin' mo' than to hol' yo' hoss—jes' say the word an' I'm with you, total, an' ef evah I git a chanct to vote fur you you kin count Brock's vote befo' you heah f'um the fus' precinck."

In the meantime General Garfield had mounted and as he dashed away he said: "Good-bye, Comrade Brock, I'll think of what you have said."

"That's right," said Private Brock to himself. "We kin do the fightin' an' one gin'l mo' or less don't make much dif. Whut's wantin' now is larnin' fur them copperhead traitors up yan."

It was not, probably, Private Brock's suggestion that caused the voters in Gen. Garfield's district in Ohio to nominate and elect him to Congress while he was yet in the field as a soldier, but they did it and they were, doubtless, impressed by some of the same influences that Private Brock had been. At any rate the young brigadier and congressmen elect went on to Washington to attend to his duties among the solons of the nation while Private Brock kept on marching and fighting with K. company of the— Kentucky. He couldn't resign and doubtless had no desire to do so. But one day two years or more after the parting of the private and the brigadier, a piece of shell, the others portions of which had taken different directions after it had exploded at Armstrong Heights, in the siege of Knoxville, came scurrying along and utterly ruined Private Brock's fatigue hat that had many brass emblems on it. The piece of shell also tore a place in Private Brock's head that was not altogether picturesque. But the surgeon in the field sewed up the rent and Private Brock did not need a hat for a long time. However, he achieved his resignation —or what was about the same thing—thru that rent in his head, which seemed to have let in new ideas. He was discharged because he was supposed to be insane, but he was impressed with the idea that he was needed at Washington to advise with Congressman Garfield and he took up his residence in the national capital.

Quickly ex-Private Brock found his self-selected protege and being recognized, the congressman gave him employment about his domestic establishment.

Aware of Brock's battle-won infirmity the statesman-general took with apparent seriousness much advice from Mr. Brock concerning the conduct of national affairs and received most humbly Mr. Brock's expressed approbation of his congressional performances.

This continued until Mr. Brock's fugleman—so to speak—had been elected President. Then Mr. Brock's responsibilities very much increased. It had been a comparatively easy matter for him to direct and instruct a mere member of Congress, but to tell the President of the United States all about what he should do was decidedly a different matter. Bravely, however, he struggled with the great responsibility until that awful day at the railway station the quixotic crank, Guiteau, fired the surgeon-made mortal shot into the breast of the gallant Garfield.

Mr. Brock was there, serving as a presidential porter, and when the assassin fired, that pitiful fool fell with a ghastly cut in his brow, into the hands of those who arrested him. He carried the scar, still crimson, to the gallows, and Brock's good right hand had made it. But the faithful ex-soldier of his country and devoted servant of his illustrious protege was taken thence to an asylum for the violently insane and died there in a week, lost amid all of the terrible excitement of the time.

Had the better light of this more scientific day been known, gallant Garfield and faithful Brock might yet have been living, hale and happy, saved by the expositions of the Roentgen ray.

THE MAN WHO WINS

The man who wins is the average man,
Not built on any particular plan,
Not blessed with any particular luck,
Just steady and earnest, and full of pluck.
When asked a question he does not guess,
He answers the question with "No" or "Yes."
When set to a task that the rest can't do
He buckles down till he's put it through.
Three things he's learned: That the man who tries
Finds favor in his employer's eyes;
That it pays to know more than one thing well;
That it doesn't pay all he knows to tell,
For the man who wins is the man who works,
Who neither labor nor trouble shirks,
Who uses his hand, his head, his eyes.
The man who wins is the man who tries.

—Detroit Free Press.

REVIEW

"ELEMENTS OF MACHINE DESIGN:"

Author Henry L. Nachman.

Elements of Machine Design: Henry L. Nachman, Associate Professor of Kinematics and Machine Design, Armour Institute of Technology. (John Wiley & Sons, N. Y. $2.00).

The advent of this compact little book by Professor Nachman should be welcomed by every teacher and student in the mechanical courses of our technical colleges. Up to this time no satisfactory text book on Machine Design has been offered, although there are many bulky and learned treatises available. Professor Nachman has reduced the non-essentials to zero, or nearly so, and has presented us with a work that is concise, readable, up-to-date, and as complete as is compatible with the brief courses in this subject that are offered in most of our institutions.

All the formulas and information necessary to a competent designer of machinery are included, and the deviations are given where it seems advisable to the author. The book is designed to meet the class-room requirements, and dces not make any pretense of being an encyclopedia of reference. The latter are numerous, and may be consulted in any technical library. Professor Nachman deserves the thanks of teachers of this subject throughout the country for providing them with a real text book, and one that is reasonable in price, no small consideration these days.

W. G. SMITH.

POPULAR PHILOSOPHY GATHERED FROM MANY SOURCES.*

"Do what you are paid to do—AND THEN SOME: It's the 'THEN SOME' that gets your salary raised."

"You will never push yourself forward in this world by patting yourself on the back."

"The man who thinks he can learn thinks a great truth."

"A gentleman is a gentleman the world over; loafers differ."

"As in a game of cards, so in the game of life—we must play what is dealt to us, and the glory consists not so much in winning as in playing a poor hand well."

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*From Dean Monin's Scrap Book.

"Most folks think if they were to live their lives over again they would do DIFFERENT; but I have never heard any of them propose to live BETTER."

"Many a man has lost a good position in this world by letting go to spit on his hands."

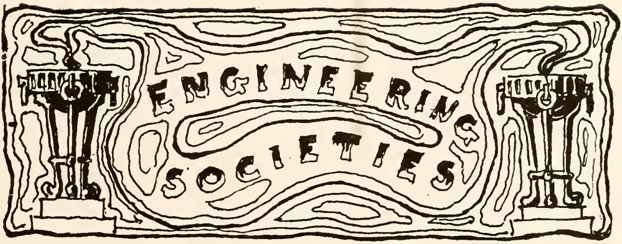
"The hardest man in this world to cheat is the man who is always honest with himself."

"Experience is a grindstone, and it is lucky for us if we can get brightened by it—not ground."

"Trusting to luck is only another name for trusting to laziness."

"He who demands respect almost always deserves it."

We recently received a letter from Mr. Roberts of the Fore River Ship Building Corp., in which he stated that, of the dozen or more colleges represented at the yards last spring, Armour Institute stands out as having sent the best men. These men showed a persistency to make good that other men lacked.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

President	K. A. Taylor
Vice-President	J. A. Keeth
Treasurer	H. Anderson
Secretary	V. A. Kerr

The members of the Mechanical Engineering Society of A. I. T. know that the war will be won mainly by engineers. They know that it has been the engineer, and the products of his thoughts, and energies, that have been one of the potent factors in shoving civilization "over the top," and especially is this so in America. So, thinking that we may be of most use to civilization and account ourselves most honorably, in the miserably short period of time that we are able to do so, we have chosen mechanical engineering as a means to this. Each member of the Society feels, with a pure spirit of patriotism, that it would be foolhardy to leave college before they were fully prepared to (and by that is meant the graduation.) By exerting a greater effort to the engineering profession we think that we are doing the better thing for the country, and mankind in general, in going to help it as trained engineers instead of unskilled men.

It was this same spirit that made a big success out of the past year, which looked so gloomy at the start.

The meetings of the past year were conducted similar to the ones of the year before, becoming the success with which this method was accompanied. At each meeting a date was set for the advance meeting and three or four members were therefore assigned to speak on some engineering subject at that meeting and to hold themselves open to discussion upon the talk. This methed of procedure was taken up with so much enthusiasm that nearly every member of the Society gave at least one interesting talk during the year.

Among those talks, which were of special notice were, "Testing and Assembling of the Fairbanks-Morse Oil and Kerosene Engine," by Mr. Taylor; "Specification of the McKinley Power Plant," by H. Anderson; "Design, Construction and Operation of the Diesel Oil Engine," by Mr. Clausen; "Operation and Construction of a Modern Dispensing Machine," by Mr. Rehfeldt; "Design and Remodeling of Valves in Motor Cars," by Mr. Wertheimer; "Lubrication of the Motor Car," by Mr. Keith; "Using the Steam Turbine as a Means of Propulsion for Ships," by Mr. Neilson; "Design and Manufacture of Piano Hardware," by Mr. Lunde; "Qualities and Manufacture of Bryn's Wrought Iron Pipe," by Mr. Kerr.

The outlook of the A. S. M. E. next year certainly is bright with having such a spirit among the members of next year's Society.

V. A. KERR, *Secretary.*

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

Chairman ....R. A. Newlander
Treasurer...H. H. Shotwell (C. P. O., U. S. N. R.)
Secretary ....A. A. Hofgren

The Armour Institute Branch of the A. I. E. E. held many well attended meetings during the year 1917-18. The policy of the organization was to obtain good speakers from outside rather than use our own local talent among the seniors.

Due to the absence from school of Mr. E. A. Moore, Jr., the Chairman elected last spring, it became necessary to fill this office at the first meeting; Mr. Newlander was elected.

The manufacture, installation, and operation of electrical devices were all discussed during the year as well as some of the newer theory along the line of thermo-ionic devices.

Our social side was not entirely neglected for we had one smoker, which was well attended and much enjoyed.

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	J. Nitka
Vice-President	H. A. Peterson
Recording Secretary	L. Weiss
Corresponding Secretary	B. B. Cramer
Treasurer	V. M. Crown

BOARD OF DIRECTORS.

Asso. Prof. M. B. Wells	Faculty Member
Student Member	L. C. Bush

A review of the meetings of the Society for the years 1917-1918 is as follows:—

Oct. 2, 1917—The first meeting of the year as usual was given over to a smoker, refreshments, and invitation to new members.

Oct. 16, 1917—Mr. L. Weiss gave a talk on his experiences, during the summer vacation, in connection with work for the Santa Fe and Rock Island R. R. Topics such as cross-sectioning, ballasting, bank widening and bridge surveys were discussed.

Dec. 4, 1917—Prof. Dean gave an interesting talk on "The Construction of the Sixth National Army Cantonment at Camp Jackson, South Carolina.

Dec. 18, 1917—Mr. Blackwood, of the Barber Paving Co., gave an instructive talk, accompanied by six reels of pictures, on "The Mining, Refining and Application of Trinidad Lake Asphalt.

Feb. 19, 1918—A joint meeting was held with the Armour Branch of American Institute of Electrical Engineers. The speaker, Mr. Rahn, gave a very interesting talk on "Manufacturing Methods."

April 2, 1918—Mr. O. O'Grady, Armour, '17, gave a talk on "Engineering Possibilities in South America." Special emphasis was given regarding the undeveloped resources and waterpower of the Southern Continent which yet require the Engineer, Farmer and Industrial man to develop them.

B. B. Cramer.

THE CHEMICAL ENGINEERING SOCIETY
ARMOUR INSTITUTE OF TECHNOLOGY

President	F. R. Johnson
Vice-President	C. W. Muehlberger
Secretary	W. W. Koehler
Treasurer	A. Pearson

The last meeting of the Armour Chemical Engineering Society was held on March 28th, 1918. Dr. Harkins of the University of Chicago completed his interesting lecture on "The Periodic System," which he started December 15th, 1916. The topic was represented from an entirely new point of view, and the arguments were based on experimental data recently determined by the doctor and his colleagues. The lecture may be summarized as follows. The first point that was made was the effect of the concentration of the atoms in a molecule, and how the concentration affects the melting point, coefficient of expansion, etc. It has been found from experimental data that the more concentrated the atomes are arranged in the molecule, the smaller the coefficient of expansion, the higher the melting point, etc. Therefore it is important for constructional purposes to choose the material which is highly concentrated.

The next point was a discussion of the electrical charges of the particles in an atom. The atom consists of a group with central nucleus having a positive charge, and surrounding particles with negative charges. The hydrogen atom consists of a nucleus having a positive charge, and a particle having a negative charge. Helium has a nucleus of two positive charges surrounded by two particles having each a negative charge. Lithium has a nucleus with three positive charges, and three negatively charged particles. One of these negatively charged particles is the valence electron, and is therefore farther away from the nucleus than the others. When the atom has a valence greater than one, then there are a corresponding number of valence elections which are more distantly removed from the nucleus. In the heavier elements the pendulum is shorter, hence the vibration is greater, and it has been noticed that the radium elements shoot out particles which have been identified as helium, and formed the second lower element. It has been thought that all elements are built up of hydrogen atoms. The following is a table showing the products obtained from the loss of particles of an atom:

Group	Atomic No.	Name	At. Wgt.	Nucleus	Charge	Electrons inner	Electrons outer
6	92	Uranium	234	$(RB)_n+5$	$82+10=92$	86	6
4	90	Ironium	230	$(RB)_n+5$	$82+8=90$	86	4
2	88	Radium	226	$(RB)_n+3$	$82+6=88$	86	2
0	86	Nitron	222	$(RB)_n+2$	$82+4=86$	86	0
6	84	Radium (a)	218	$(RB)_n+1$	$82+2=84$	78	6
4	82	Radium	214	$(RB)_n$	82	78	4

When an atom loses an alpha particle with two positive charges, the atom will decrease in atomic weight by four, and helium is the particle lost. If however a negative or beta particle is projected from the system, only 1-1845 part of the original weight of the atom is lost.

The alpha particles travel at a rate of 20,000 miles per second, and have a diameter of 10^{-8} cm., while the negative electron has a diameter of 10^{-13} cm. When a uranium atom loses an alpha particle, the resultant atom formed is that of Ionium which is in group four, and the second lower element, the atomic weight is decreased by four, and two positive charges are lost, the inner negative electrons remain the same but the outer are decreased by two. This is typical as the atom loses the alpha particles of two positive charges.

If we try to build up the atom, we find that we do not jump up in twos but go up in steps of one. The even numbered elements increase with fair regularity by four in their atomic weight as shown by the following table.

	Atomic No.	Atomic Wgt.
Helium	2	4
Glucinum	4	9
Carbon	6	12
Oxygen	8	16
Neon	10	20
Magnesium	12	24
Silicon	14	28
Magnesium	12	24
Silicon	14	28
Sulphur	16	32
Argon	18	40

This is also true of the uneven numbered elements as shown by the following table:

	Atomic No.	Atomic Wgt.
Lithium	3	7
Boron	5	11
Nitrogen	7	14
Fluorine	9	19
Sodium	11	23
Aluminum	13	27
Phosphorus	15	31

It has been found that the even numbered elements are more stable than the uneven elements, and also that they occur in larger aboundance in the earth's crust. The seven most aboundant elements are iron, oxygen, silicon, magnesium, calcium, nickel, and surphur; composing 98.6% of the earth, and the remainder (1.4%) consisting of other even numbered elements and the total of all the uneven numbered elements. The uneven numbered elements above or below it in the atomic number. W. W. K.

ARMOUR FIRE PROTECTION ENGINEERING SOCIETY.

President	F. A. Trask
Vice-President	L. V. Kuttnauer
Secretary	R. N. Mann
Treasurer	C. W. Mintz

The Freshman Class was taken on an inspection trip to the testing station of the Underwriters' Laboratories, Inc., on May 2, under the direction of Prof. J. B. Finnegan. During the visit a standard partition test was run. The partition lasted 2¼ hours in the furnace, but disintegrated under the hose stream. A fireproof safe was also tested. It was heated in a furnace one hour, and then dropped to the ground from a height of fifty feet. The doors were slightly bulged in the fire test, and were bulged somewhat more in the falling test.

The National Fire Protection Association has its annual meeting the 7th, 8th and 9th of May at the Auditorium of the Insurance Exchange. All members of the A. F. P. E. S. would do well to attend this meeting.

A lecture on "Insurance Contracts" will be given shortly before the A. F. P. E. S. by Attorney F. M. Fairfield.

ARMOUR SOCIETY OF ARCHITECTURE.

W. C. Wright	Massier
A. R. Monaco	Treasurer
L. E. Twery	Secretary
S. C. Hulburt	P. A.

It may be of interest to the engineering students and others to know the nature of the problems in the department of architecture. The present Junior and Senior problem is herewith published to aid in giving an idea of the architectural school work.

An architectural drawing is a scheme of indication illustrating what the architect's ideas are as to the solution of his problem. An architectural drawing is not a finished masterpiece of painting or drawing wherewith the ultimate purpose of the work terminates in the drawing itself. It is the aim of the class to keep constantly in mind the function of architectural indication. The work is of an extremely practical nature.

Items of special interest will be noticed in the following problem:

1. Special foundation footings for independent structure containing bodies. Their structure is independent of the building proper.

2. Ventilation pipes for disposal of gaseous products of oxidation of bodies.

3. Crypt.

4. Service corridor behind tombs to facilitate cleansing of ventilation and sewerage services.

The Problem:—

1918—ANNUAL TRAVELING SCHOLARSHIP COMPETITION.

(Open to Juniors and Seniors.)

"A PUBLIC MAUSOLEUM."

TIME:—Preliminary Sketch March 18th.

Finished Drawing due May 13, at 9:30 P. M.

Subject:—

In the Middle West have been built a number of mausoleums in which space is rented for appropriate burial of either single space or several spaces in groups. These schemes have been built by private individuals for gain and so far are totally unworthy examples of architecture. In the Anicent times private associations were formed for the erection of such mausoleums in order that individuals might be buried in more suitable style and greater security than would be possible by the single individual. It is such an association that intends to erect this public mausoleum, or in reality, a mausoleum for its own members.

One must not be misled in the composition of this museum by the mausoleums designed by a nation for a single individual. In this problem it is the expression of many individuals, all of whom are to have the same approximate honor done them in their burial place. In the design the practical and aethetic requirements should be met in the plan with the study of the construction and materials used which will indicate the nature of the style rather than any definite attempt to imitate a historic syle.

REQUIREMENTS:—

Level Ground.

2500 to 3000 burial spaces.

Inside dimensions of tombs 7′2″ x 2′ 2″x3″, arranged in four or five tiers, with ends towards corridor. A chapel to seat approximately 300, with crypt below for usual mortuary chapel purposes. A service corridor at least 2½ feet wide; have ventilation pipe ducts; passage for person must be behind all the sepulchre tiers. The building will be controlled by one or two guards and a single entrance closed by a grille or bronze doors seems most desirable. A simple heating plant is necessary for the chapel in basement.

CONSTRUCTION:—

The construction will be of concrete faced on the exterior with stone or marble and on the interior with marble. The foundations for the sepulchre tiers must be independent of the foundations of the building. It seems most desirable that the corridors be vaulted, but this is not mandatory. The lighting must be carefully considered, if overhead in the vaulting, the openings must be glazed somewhat like sidewalk lights. Openings in side walls need not be glazed but must be closed with grilles.

Enormous spaces or lengthy corridors are not desirable as too many persons visiting at the same time in the same corridor or room are likely to disturb one another. The series of chambers containing tombs connected by main circulation seem most desirable. The form may be such that courts develop into dignified gardens or may occupy certain areas. Position of chapel is not fixed, but must be connected with main circulations. The Entourage of the mausoleum will be developed as part of a cemetery and must be shown in the final drawing. For the preliminary drawings, plan, elevation and section in ink on one sheet of tracig paper at 1-64th scale. Competitors are not to see each other's sketch but may consult as to the program. The final drawings, plan and section at 1-16th scale. Elevation at 1-8th scale.

A. B. Greenleaf.

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SELECTED LIST OF BOOKS ADDED
NOVEMBER, 1917-APRIL, 1918

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THE ALUMNUS

Being That Part of **The Armour Engineer** Devoted to Personal Mention of the Graduates of the Armour Institute of Technology and to the Affairs of the Armour Alumni Association.

Edited by the Publication Committee of the Armour Alumni Association.

J. J. Schommer Grover Keeth E. G. Hindert

Communications should be addressed to J. J. Schommer,
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ALUMNUS.

The time for our spring meeting is approaching. While our Constitution provides that such a meeting be held, the question was seriously discussed by your board of managers of taking the responsibility of not holding a meeting, the reasons being that a large number of our members are out of the city, either on war production work or in government service, that a large percentage of the senior class have already left, and the increased cost of providing a dinner. It has even been almost impossible to hold a meeting of the board of managers on account of the absence of members from the city.

However, due to the fact that there are a number of important matters which require your consideration, it has finally been decided to hold a business meeting on Thursday evening, May 23rd, at 8:00 P. M., in Science Hall.

At this meeting action will be taken on amending our constitution to dispense with the December meeting, and our financial condition. Certain action regarding the Alumni loan fund is necessary, as is also the question of support for the school publication, "The Armour Engineer." This publication has reached a high standard, is facing a trying situation, and should not be allowed to decline.

It is intended at this meeting to have a talk by a representative of the faculty as to how the Institute has aided our government in the prosecution of the war and what it is prepared to do in the future. It is also planned that we have a speaker who will tell us about some important phase of our participation in this Great War.

There will be no charge for this meeting, but our Treasurer will be in a prominent place for the receipt of dues, of course we shall be pleased to receive a remittance if you cannot be present.

The presence of every Armour Man is earnestly requested at this meting—don't forget the date—May 23rd, at 8 P. M., in the Institute. COME OUT AND KEEP THE HOME FIRES BURNING. —*Grover Keeth.*

ALUMNUS NEWS.

Mr. A. L. Kubitz has left the Inspection Department of the Public Service Company to act as Assistant Service Engineer of the State Utilities Commission. He will be located in the Insurance Exchange Building, Chicago.

Messrs. F. O. Godfrey and D. A. Whittaker are in the Testing Department of the Public Service Company.

Mr. R. B. Wendell has been transferred from his position as Station Electrician of the Public Service Company, to the General Superintendent's office.

"Stuart N. Miller, C. E., 1917, is now in France with the 509th Engineers Service Battalion, which sailed about the first of March. He is having many interesting experiences, such as attempting to make purchases in the little French Shops. Once he tried to buy a half franc's worth of almonds, and the madam had great difficulty in explaining that a franc's worth was the least he could buy."

Through the courtesy of Mr. and Mrs. David T. Kiley, we are enabled to publish the following very interesting letter from their son, LeRoy D. Kiley, '12, member of the Expeditionary Forces, in France.

ON ACTIVE SERVICE WITH THE AMERICAN EXPEDITIONARY FORCE.

Foggia, Italy, December 10, 1917.

Dear Mother and Father:—

* * * * * *

Yesterday morning I started out for an altitude flight and my engine died on me when I was about three hundred feet up and I landed in a pasture in a flock of sheep which, needless to say, scattered in every direction. I had to sit there in the machine until another machine flew over with a "motorista." After he fixed me up I went back to camp as it was lunch time.

Yesterday afternoon I started out again for my altitude flight in another machine. I climbed to about seventy-five hundred feet and was far above the clouds and still climbing when I found the wind had shifted the clouds over the entire sky, so there I was sailing along and lost above the clouds. I did not worry much because I knew I could fly to an open spot somewhere and plane through but it was getting late and I knew it would soon be dark.

While I was sitting there planing down slightly and with my engine half open looking for an open hole in the clouds, suddenly my engine ceased running. So I nosed the machine over and planed through the clouds with a dead stick. When I came through on the other side, lo and behold—it was almost entirely dark. You see the sunlight up high on the tops of the clouds made it very bright where I had been. I looked around the country as I planed down and could only make out the white roads, it was so dark, and furthermore I could not get my bearings as the country looked all strange to me.

I steered away from the white road for fear there might be telegraph wires along it, and then went into a spiral over a dark stretch of ground which in the semi-darkness looked clear. I was so intent on looking for a good landing place I spiralled pretty steep and consequently was going like everything. I leveled out and was landing fine when I saw about a hundred yards ahead of me a group of buildings. I was traveling about sixty miles per hour and there was no turning at that stage of the game as I was too close to the ground, so I attempted to shoot through the front yard between two buildings and go on beyond. In the darkness I did not see a wagon standing near one of the buildings and my left wing caught it. From then on the fun commenced. My machine turned the wagon over dragging it about fifty feet and meanwhile my plane was going to splinter wood in every direction. The wagon turned me to the left at right angles to my course, sweeping off the landing gear and folding back the left wing into a pile of canvas and broken struts. My right wing went into the ground and crumpled up and there I was sitting in the nacelle absolutely untouched. My motor on its frame behind me was also intact and my propeller had stopped in horizontal position when my engine quit, so it was all right.

The people rushed out of the house when they heard the awful racket and found their front yard full of airplane and certainly looked surprised. I waved my arms to show them I was O. K. and kept shouting Americans—Americans, but I guess I looked too fierce all bundled up in my leather suit, goggles and helmet, and they would not come near. So I climbed out of the nacelle to the ground—it was only a few feet up, after losing all the understructure, and walked over to them. Of course, I could not understand them, nor they me, but I took out one of my cards and wrote the number of my machine on it, and that I had smashed it up, and succeeded in geeting one of the younger members to start for town with my message.

They got out a horse and I offered to hold it while they went for the harness, but the horse took one look at me in my goggles and helmet and reared all over the place, delaying the departure of my messenger about ten minutes.

He finally got away, though, after I kept in the background. It was absolutely dark by this time and I burnt up my gloves, handkerchiefs, etc., after soaking them in gasoline from my tank so as to make flares for the searching party I knew would start out from camp.

Meanwhile there was great excitement at camp. The field was illuminated for night landing with flares and electric lights and searchlights were swinging all over the sky to give me my bearings in case I were still in the air. I was about 15 miles from camp and of course, telephone service is rare and no one had seen me come down through the clouds. Finally at ten o'clock I saw the headlights of the Major's Buick far off on a hill and so poured more gasoline on my flare and they soon reached me.

I was scared to death they would raise Cain with me when they saw that about ten thousand dollars worth of good airplane was gone to smithereens, but when they arrived they turned the headlights on the wreckage and when I walked over and saluted Captain ——— stepped out and put his arm around me, saying: "Are you all right, Kiley?" I said I was, and he said: "Never mind the plane." Captain ——— is our Italian Chief Pilot and a very fine man. My Major, Major ———, merely said—you're a lucky chap, Kiley, and offered me a cigarette. I did not expect to get off so easy, and I was sure relieved. A few moments later another car arrived with a guard for the machine and the major and the captain took me back with them in the Buick. That Buick is a good little bus and we certainly did hit it up on the way back to camp.

Today Lieutenant Cheney—an Italian Lieutenant, and I went out again and a truck and a trailer followed us to bring back the machine. I got some good pictures before they dismantled everything, but I do not suppose the censor will permit them to go through the mail.

I was not the only one playing in hard luck yesterday, for another man had a propeller come off when he was 12,000 feet up on his second brevet cross country test. He landed O. K., about 40 miles from here, and returned today.

Our machines are certainly great training planes. No matter what happens to the machine—landing gear, wings or what not, the nacelle remains intact and the pilot is always O .K.

* * * * * *

I had some dandy flying this morning—was the first one up in our squad—just at sunrise. Last evening just before sunset I had a fine joy ride with one of the chief pilots. I sat out in front in the observer's seat and had nothing to do but look around. We left the field headed for the mountains in the west climbing all the time. After we reached about 2500 feet he turned back toward the town of Foggia.

The country looked mighty pretty at that time of day. The fields looked like little colored pieces of a puzzle picture all laid out zig-zag and fitting so evenly into one another. The roads are pure white and all ran toward the town of Foggia from as far as you could see, just like the spokes of a wheel.

We could see a train flying along but it merely seemed to crawl, from the height we were at. The school machines flying around the field looked like big bugs way beneath us. I had nothing to do but look around so I examined everything—all the instruments, etc., and then looked over the side and examined the landing gear and planes. The pilot and I talked back and forth by signs as he pointed out different things to me. Finally while still at our altitude of 2500 feet he cut the motor and glided all the way back to the field sometimes making a spiral to the left and sometimes to the right. It is great sport gliding in as the motor is cut off and there is no deafening roar, only the wind whistling through the wires. We have excellent machines here, all new and equipped with —— motors,—the best in the world.

* * * * * *

March 8, 1918.

This noon we heard the roar of a big motor and since none of our training planes were flying—owing to low clouds—we rushed out to see what was coming in. You can imagine our surprise to find it was an English speed tractor driven by Lt. ——, who had flown down here from London with one or two stops. He landed beautifully—stepped out in a flying coat and helmet, which he immediately took off, and passed to "Hatch," his sergeant, who was in the observer's seat. "Hatch" handed him his uniform cap and "cane" and he walked in off the field as nonchalently as you please. There was no bravado about it at all and he was just acting as natural as you please. I tell you, you can't beat these English chaps, they are a cool, nervy bunch. His coming has been heralded in the newspapers and he has had some wild adventures, such as landing in a snowstorm in the Alps and surrounded by wolves which they frightened off with their machine gun. He spoke of the incident in a most unconscious and humorous manner, referring to the wolves as "rotten dogs." He was a scream every time he spoke, and yet utterly unconscious of the humor of his remarks. We asked what kind of a trip he had had on this last jump and he said, "It was a bit of a bore, you know—the bloody engine vibrated (because of a loose propeller) and I had to jog along, just skimming the blasted foothills" (our mountains). We asked him how many bombs he carried and he started to answer, then looked up in air, scratched his chin and finally turned and said, "I say, Hatch, 'ow many bombs do we carry"? Hatch is an all around man—expert motor mechanic—knows just what the lieutenant wants, and can answer any question. The humorous part of Lt. —— is that he would ordinarily impress you as being a "bonehead" unless you knew he was a great military pilot and further, that with all his apparent "simplicity" he is keen as can be.

That's the way with these English, they do not exaggerate anything, in fact minimize most things, so that you can't help but like 'em. There is some prejudice among a few of the other nationalities against them here in Europe, but I think it is because they do not get the humorous side of them as we Americans do.

Rome, Italy.

Letter to Frank ("Duke") Cooban, '15.

Just thought I would drop you a line from this Rome place. It is a nice little town, and I like it considerable. It is a hard life to be one of the only two American soldiers in Rome at present writing and flashing the aviation eagle around on our hearts.

Went out to the little old Coliseum this morning, and saw where the gladiators used to gladiate. It makes a nice little building about twice as big as ours in Chicago, and oval in shape. Time was when the seats, boxes, etc., were faced with marble, bronze, gold and silver, but some Emperor or other, took most of it to build himself a house. Saw the ruins of same, and from the extent thereof must have had a large family. Another guy, also an Emp., later built his house right in the middle of the Arena of the Coliseum, using the Coliseum as a fortress or wall around him. The ruins of this old palace are still within, and he must have had one or two workmen on the job from the size of his residence.

Going down to dinner—Oh Boy! Solid gold meal, beautiful women in evening clothes, and all men in uniform except a few ambassadors in waiters' clothes. As per before "The American Aviators" were objects of much lorgnetting. We are not commissioned yet, but with officers' uniforms minus bars and shoulder straps of our Sam Browns, we are on the dividing line, so that the common herd were doubtful. However, our status was cinched when a Major came in (U. S. A. and "Americanos") and shook hands with us. After gambling with the Italian menu, and, luckily, obtaining regular food, we repaired to the drawing room for our coffee and cigars. You should have been there. Every one followed our example (as we beat them to it) and the beautiful women (smoking beautiful cigarettes) with the chatter of many foreign tongues, was—well, as you and I would say—"ee-clatt." I won his everlasting friendship by offering him a Fatima (unprocurable in Italy).

Next thing we knew another American from our camp drifted in supporting Gouverneur Morris, the author, and they joined us. Morris was rather—well,, I should say, indefinite in his purposes, but most cordial, in fact friendly to the extent of familiarity. Said Americans had just arrived in Rome and they were going a little Rome-ing. You know when you are in Rome you are supposed to do as the Americans do.

We sat around until 10:30, when all the lights were put out (war measure, I presume), and then came up here to my room. I have just taken my warm "bawth," and am finishing your letter. Hence, I shall return to the day's travels.

After examining the Coliseum minutely for thirty or forty minutes we went to the old Roman Forum, where old man Caesar cashed in and Marc made his speech, so that Bill Shakespeare could make something on the account of it all.

Say—those old Romans were some artists with the trowel and mortar. Come to think of it, though, most of these old buildings were built without mortar, same as Coliseum. Next we went up to Capitoline Hill and saw the gold plated (no joke) bronze statue of Marcus Aurelius riding his nag. Here also is the tower where old Man Nero played in the jazz band when he had Rome all lit up.

I used the new stereoscopic camera extensively hereabouts same as in Coliseum and Forum. Emp. Constantine had his gang put up a nice little arch at foot of hill near Coliseum, and we marched thru it to dodge the fifty first Roman selling cameous and mosaics. We then chartered a horse drawn equipage and traveled out via the Appian way to the Catacombs. These are nice little jobs of tunnelling four or five stories below ground to furnish repository for houses, etc., of the dead ones. Saw original bones only recently excavated, and got candle grease from my taper all over my new gloves. Went further out Appian way and saw more tombs, churches and other ruins. A ruin here is a ruin. Push the Continental Commercial over and you have a miniature ruin compared with these palaces, etc.

In those days it must have been an honor to lay bricks and the kings were all heads of the unions. The Caracalla Baths evidently had it all over Monte Carlo. They only covered about one-half square mile and were built up four or five stories. Here the Patricians used to bathe, drink, court the Goddess of Fortune. Them were the golden days, no automobiles or trains, of course, but who wanted to leave Rome. There is a great deal more I could write you about, because take it from me, Romulus and Remus started something, but the Waterman is running dry.

But to go back, why am I in Rome? Ah! Three days leave after passing 2nd brevet—now a full fledged military aviator. Tomorrow St. Peter's and the Vatican, the wonder places of the world. Let Billie Hill read this, as I have thought of you both in writing—we must all come over here again some day. We need about a month in Rome, a month in Paris, London, Naples, well a year would do nicely. We may want to see the ruins of Berlin too, then.

(Signed) "Speck" L. D. Kiley, A. I. T.

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